PETROLEUM PROCESSING

VOLUME 3, NUMBER 6

TECHNOLOGY DEPARTMENT

JUNE, 1948

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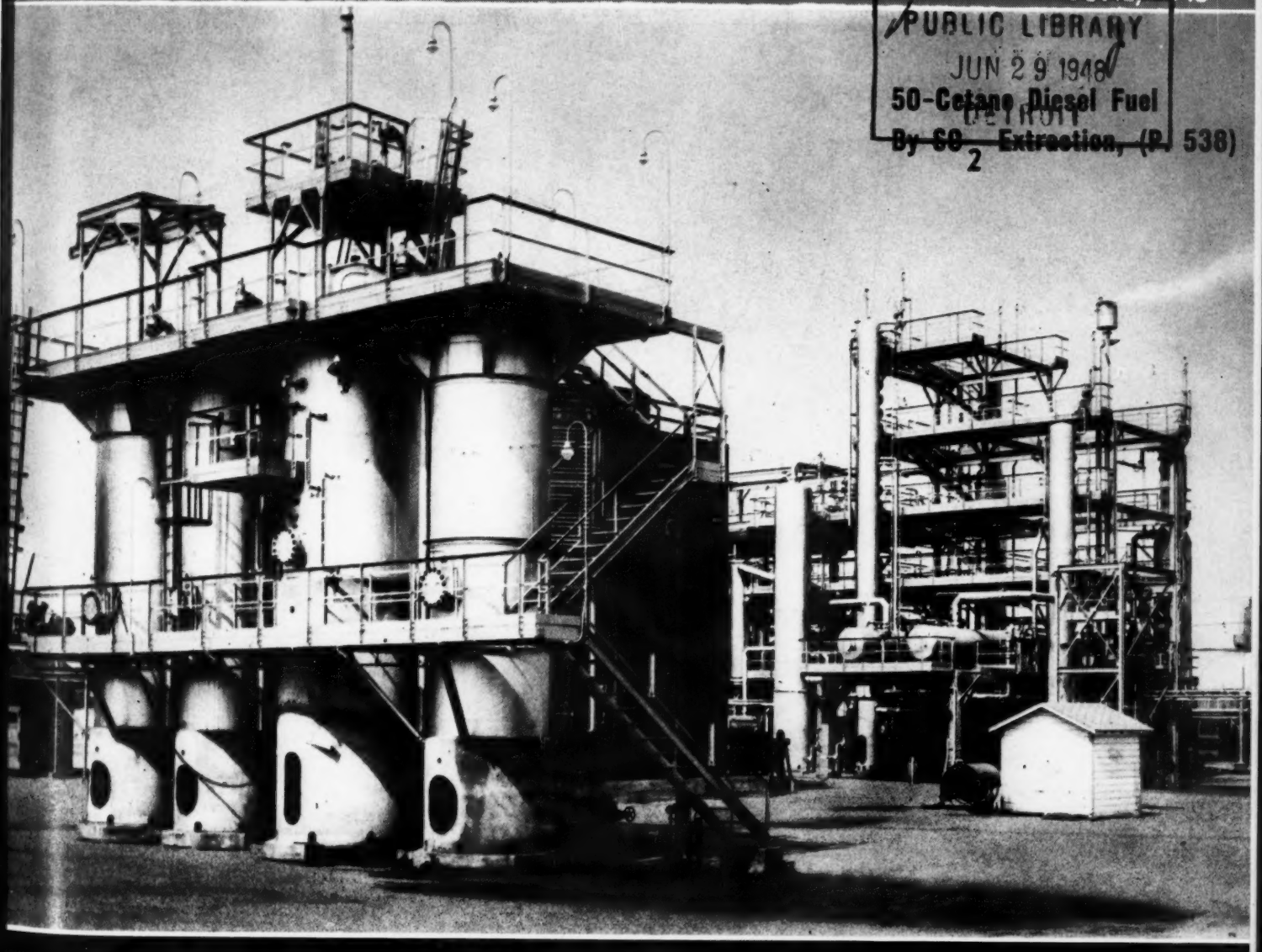
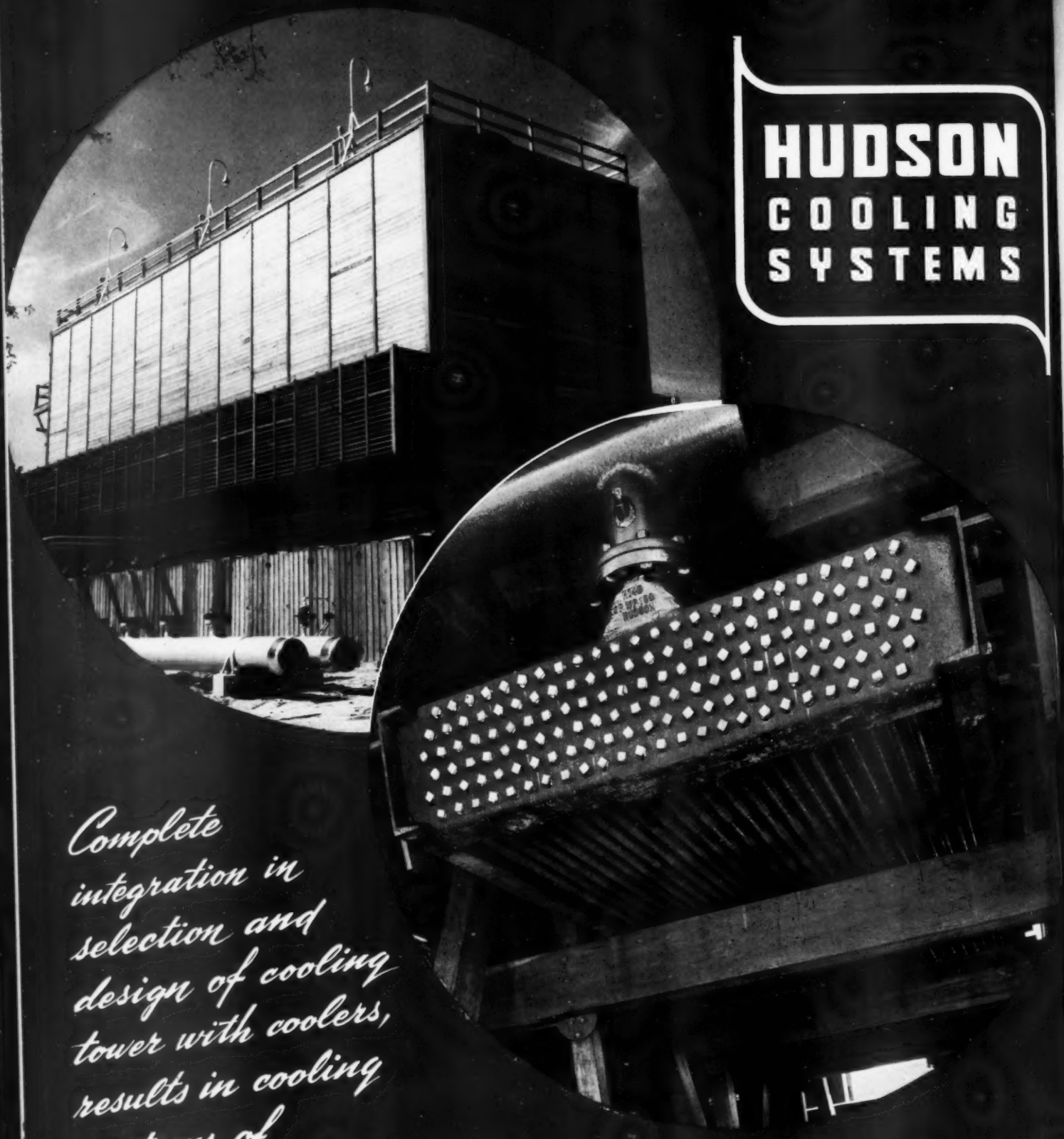
DETROIT

50-Cetane Diesel Fuel By SO_2 Extraction, (P. 538)



FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

HUDSON COOLING SYSTEMS



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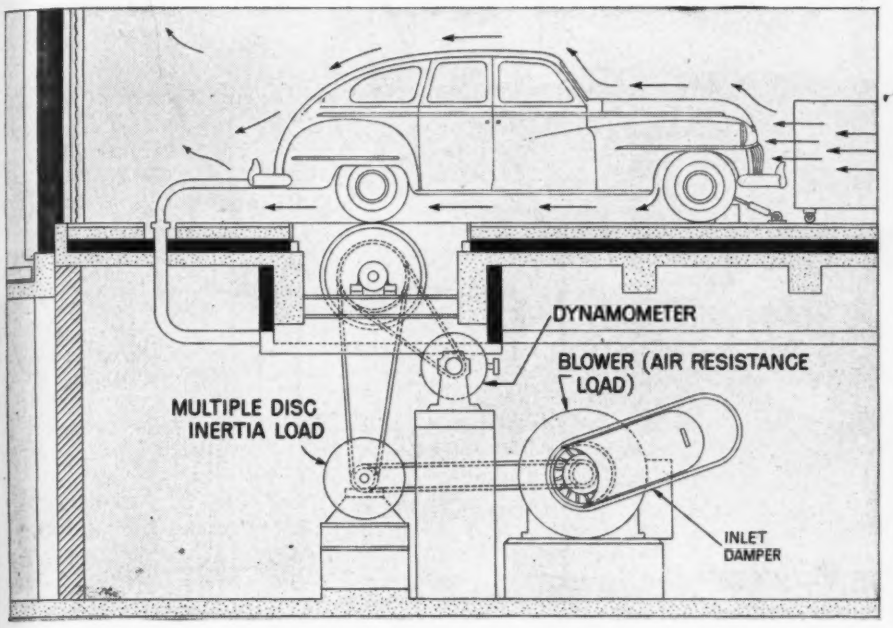


Fig. 1. *In the "cold room" the chassis dynamometer rolls are connected to an adjustable flywheel, made up of sets of demountable discs, which substitute for the inertia of the car on the road. A blower also connected to the rolls simulates air resistance.*

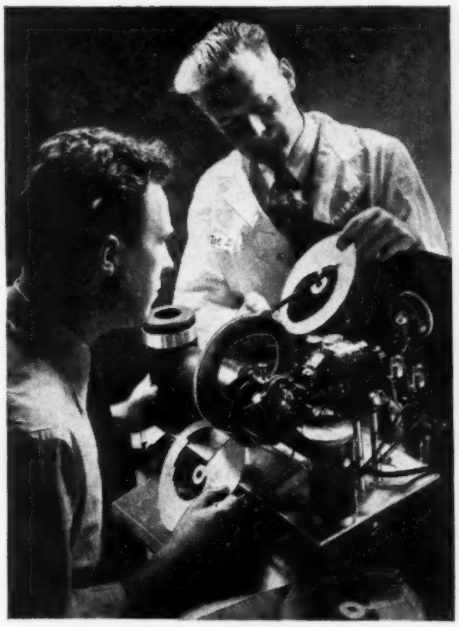


Fig. 2. *In the "hot room," vehicle speed-time relationship during acceleration on the dynamometer is controlled by an electronic mechanism.*

WINTER *or* SUMMER, *Ethyl's chassis dynamometers duplicate indoors any desired driving conditions for accurate road knock ratings.*

MANY COMPLICATIONS often delay road knock testing in fuel development programs. (1) Traffic interferes; (2) Prevailing atmospheric conditions may be unsuitable; (3) Daily weather variations affect the reproducibility of results; (4) Visibility or road traction may be unfavorable; (5) Frequent sudden stops cause rapid brake wear.

Outdoor Results with Indoor Convenience

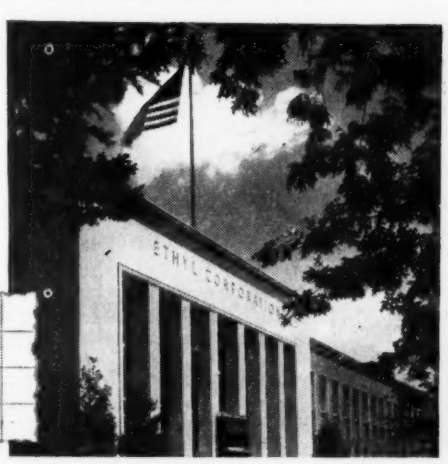
In order to circumvent these obstacles, the Ethyl Corporation Research Laboratories at Detroit have developed two types of chassis dynamometers on which to do "road" knock testing indoors. Knock ratings obtained on this equipment—on fuels made by a wide variety of refining processes—are as close to average road ratings as road measurements themselves. Thus Ethyl's "indoor highways" provide an accurate means for "road" knock testing every day in the year and with substantially any desired "weather" on a road having any desired grade.

Special Equipment Provides Automatic Control

On one dynamometer (Fig. 1) the speed-time relationship is controlled mechanically, whereas on the other it is controlled by electronic means (Fig. 2). In both installations the velocity of the air blown against the front of the car is synchronized electronically with the rear wheel speed. Temperature of the cooling air also is controlled automatically. Acoustical treatment of walls and of air blowing equipment minimizes noise, and permits accurate detection of audible knocking by observers. Braking is accomplished through electrical loading of the dynamometers, thus avoiding rapid wear on the brakes of the test vehicles.

The development of this specialized equipment, which is used to aid refiners in research directed toward economical manufacture of acceptable fuels, was made possible by more than twenty years of experience in the Ethyl Laboratories on the interrelated problems of fuels, lubricants and engines.

Ethyl Corporation's Laboratories at Detroit are designed for comprehensive research and service on problems related to fuel-engine-lubricant interrelationships.



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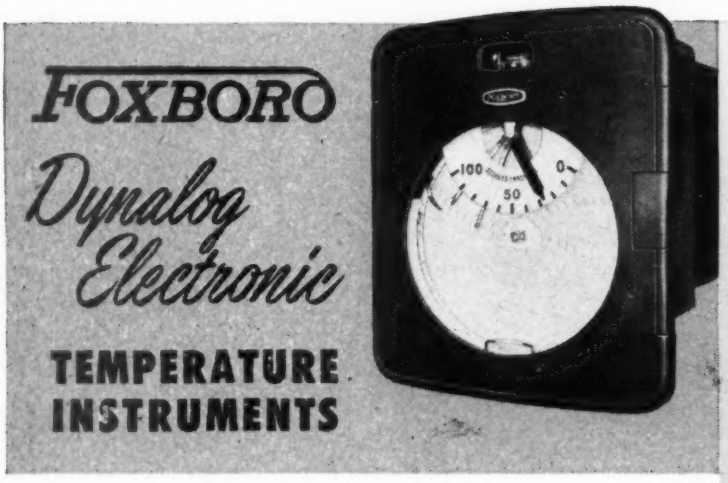

HIGH RANGES . . . LOW RANGES . . . IN BETWEEN— the unique advantages of Dynalog Electronic Instruments are adaptable to practically any process having temperatures to be measured, recorded, or controlled *exactly* and *fast*. Using either thermocouples or resistance bulbs, these instruments are unequalled in their flexibility of application—just as they are in their combination of accuracy, sensitivity, and speed of response.

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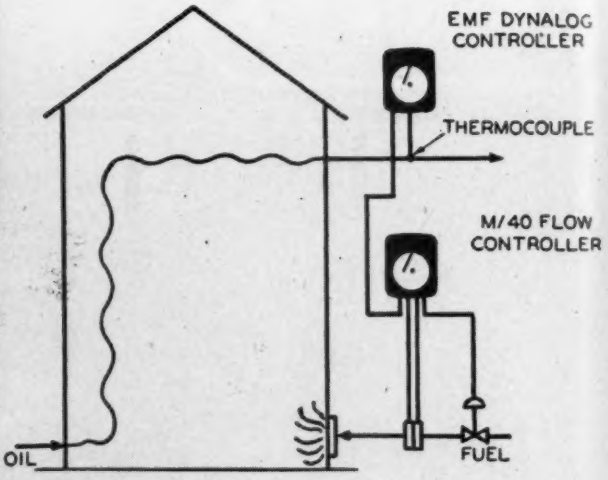
Using other primary elements, Dynalog Instruments are available for the measurement or control of pH, flow, pressure, and other process variables. *Write for Bulletin 397.* **The Foxboro Company, 246 Neponset Avenue, Foxboro, Mass., U. S. A.**



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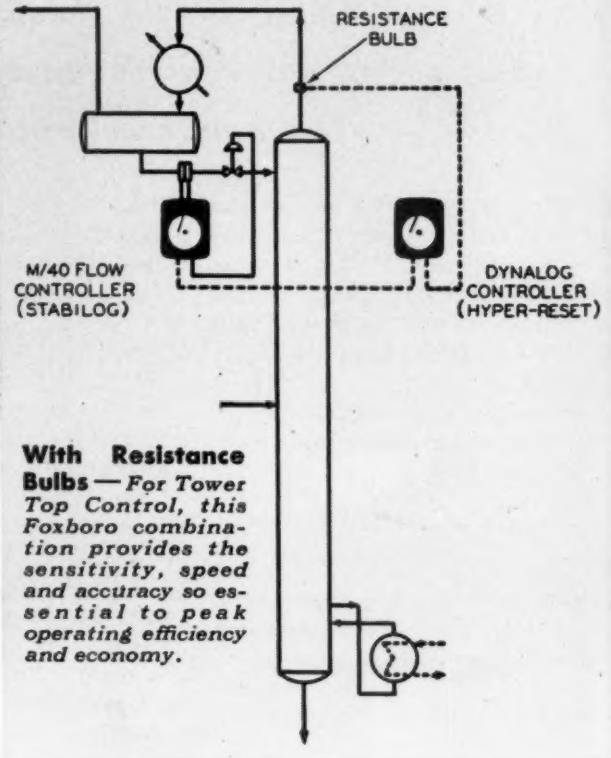
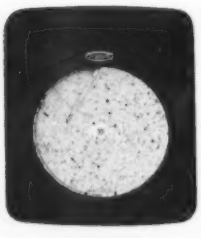


With Resistance Bulbs—*For Tower Top Control, this Foxboro combination provides the sensitivity, speed and accuracy so essential to peak operating efficiency and economy.*



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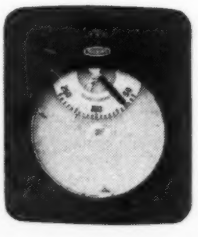
FOXBORO DYNALOG ELECTRONIC CONTROLLERS



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CCA

VOLUME 3
NUMBER 6
JUNE, 1948
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PETROLEUM PROCESSING

OTHER PLATT PUBLICATIONS:
NATIONAL PETROLEUM NEWS
OILGRAM NEWS
OILGRAM PRICES
PLATTS'S OIL PRICE HANDBOOK

Covering the Management, Design, Operation, Equipment, Products of Plants Processing Crude Oil and Natural Gas into Fuels, Lubricants, Chemicals

Contents

for June, 1948

OPERATION	Refiners' Tools, Materials for Tomorrow's Gasoline	531
	Gasoline and Cycling Plant Operations, A Question and Answer Forum Conducted by Dave Thornton	535★
	Front-End Volatility as It Effects Processing of High-Octane Fuels	565
	Tail-End Volatility of Gasoline	567
	Catalytic Polymerization and Its Commercial Application, by P. C. Weinert and Gustav Egloff	585★
PRODUCTS	Problems in the Efficient Utilization of Butanes	573
	Natural-Gas Butane and Motor-Fuel Vapor Pressures	579
PROCESSES	Operating Results on Commercial Hypersorption and Fiber Glass Desalting Are Told to AIChE	537★
	Diesel Fuel of 50-Cetane Value Produced in New Sulfur Dioxide Extraction Plant, by S. W. Dickey	538 COVER STORY
EQUIPMENT	Plant Practices—Practical Tips and Ideas	544★
	Relay Racks Make Rigid, Compact Stands for Laboratory and Pilot Plant Apparatus	546★
	Efficient Operation and Fuel Saving Feature Four-Step Oil Dehydrator *(Equipment Patent Review)*	599★
CORROSION	Prevention of Corrosion in Refinery Heat Exchangers	549
	A Resume of Sohio's Experience in Overhead Condensers	555
TRAINING	Training of Process Operators	556
	Determining Refinery Training Needs	563
DEPARTMENTS	What's Happening	523★
	Tomorrow in Petroleum Technology	527★
	Patent Trends in Petroleum Refining, by Peter J. Gaylor	595★
	What's New! Equipment, Materials, Processes, Literature	601
	Meetings for the Oil Man	611
	New Books for the Oil Man	611
	Petroleum Technologists in the Headlines	613
	Advertisers' Index	615
	Editorial Viewpoints	616★

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OFFICE: 1213 West 3rd St., Cleveland 13, Ohio, telephone CHerry 7672; Editorial Bureaus—50 West 50th St., New York 20, N. Y.; 1046 National Press Bldg., Washington 4, D. C.; 59 East Van Buren St., Chicago 5, Ill.; 904 World Bldg., Tulsa 3, Okla.

Published the first Tuesday of each month by The National Petroleum Publishing Co., 1213 West 3rd St., Cleveland 13, Ohio. Subscriptions: $3.00 a year in United States and possessions, $3.50 a year elsewhere. Single copies, 35 cents each; back copies more than three months old, 50 cents each. Published prior to Sept., 1946, as the Technical Section of National Petroleum News, devoted to REFINERY MANAGEMENT and PETROLEUM CHEMICAL TECHNOLOGY and including International Petroleum Technology. Trade mark registered U. S. Patent Office. Copyright 1948 by The National Petroleum Publishing Co. Acceptance under the act of June 5, 1934, at Cleveland, Ohio, authorized Jan. 15, 1948

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176 DAYS ON STREAM

10 DAYS TURNAROUND

4,508 MAN HOURS REQUIRED FOR TURNAROUND

93% OPERATING EFFICIENCY

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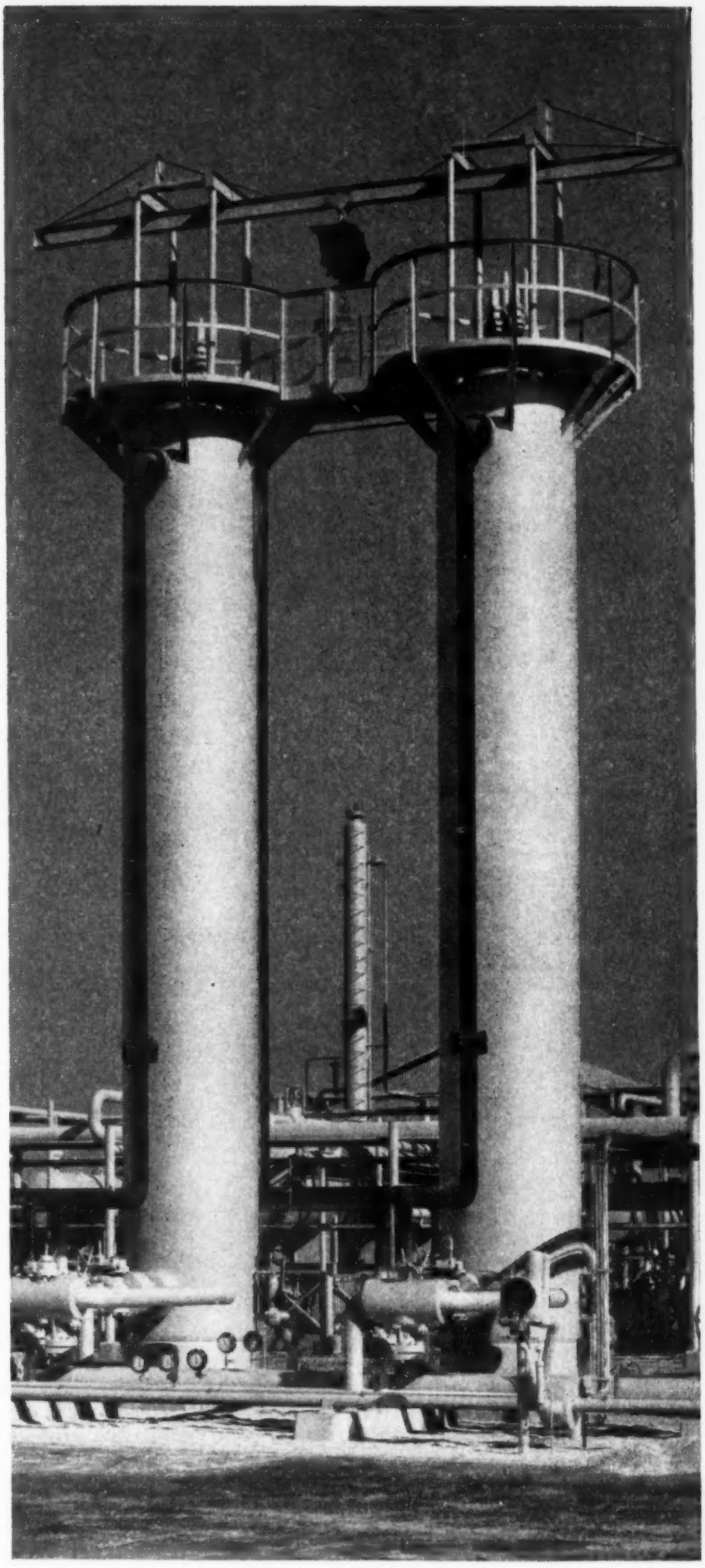
The two 4½-ft. by 33-ft. dehydrator towers shown at the right were built at one of our plants for the Arkansas Fuel Oil Company's Panola gasoline plant near Carthage, Texas. Designed with a capacity of 100,000,000 cu. ft. per day, this modern plant now processes gas from 28 wells, which is delivered to it under 1050 lbs. per sq. in. pressure. After passing through an absorber, the incoming wet gas is delivered to one of the two dehydrator towers, both of which are packed with activated bauxite desiccant. About 10 per cent of the inlet gas is diverted for use as a regenerating medium. Provision has been made to allow one dehydrator tower to be in operation while the other is being regenerated.

Designing, fabricating and erecting steel plate structures to function under a wide range of pressures and temperatures is an important part of our complete service to the petroleum industry. May we work with you on your next job?



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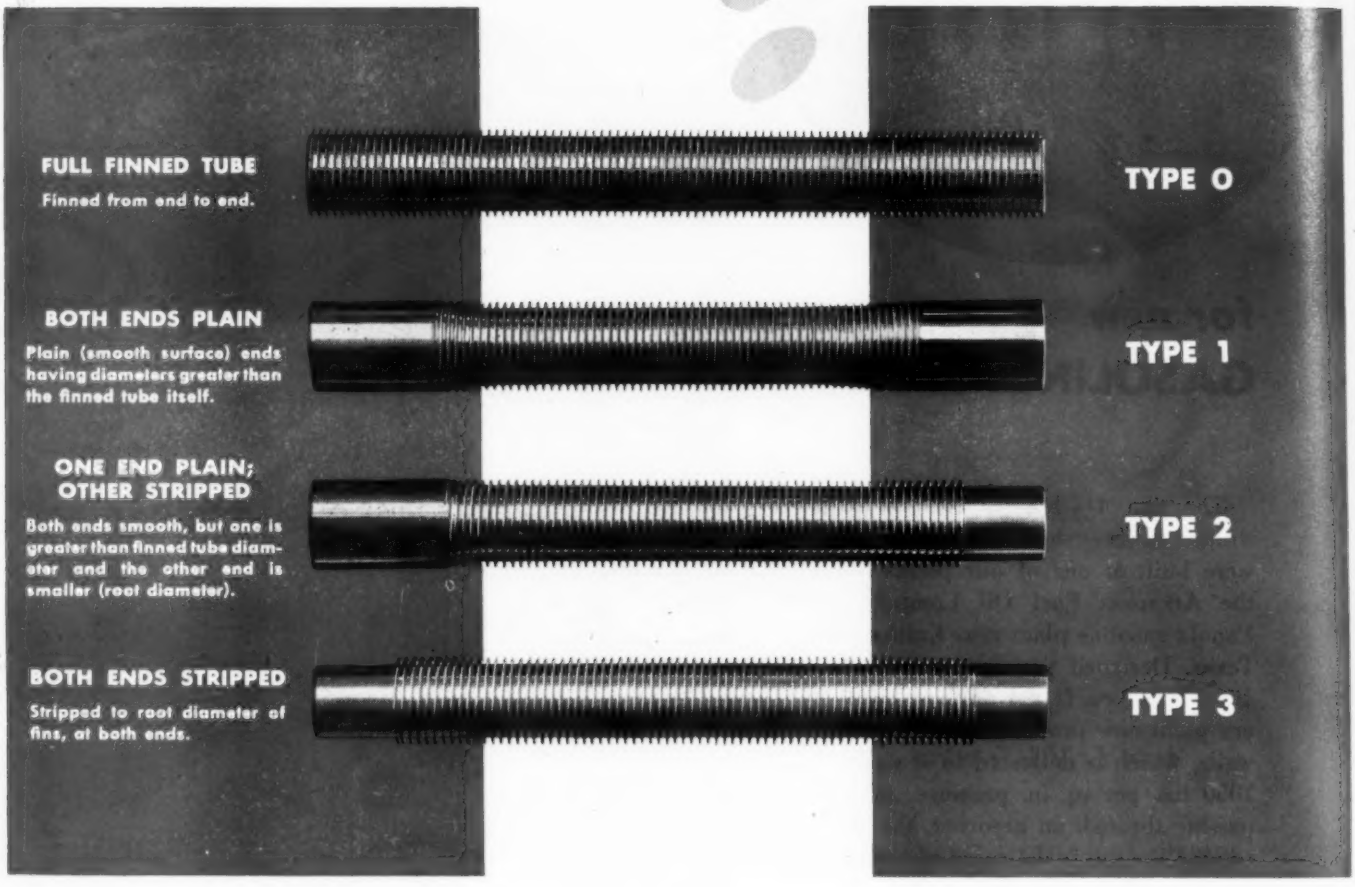
FULL FINNED TUBE
Finned from end to end.
TYPE O
BOTH ENDS PLAIN
Plain (smooth surface) ends having diameters greater than the finned tube itself.
TYPE 1
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Send for Brochure K-6 which gives helpful information to users of condenser tubes.

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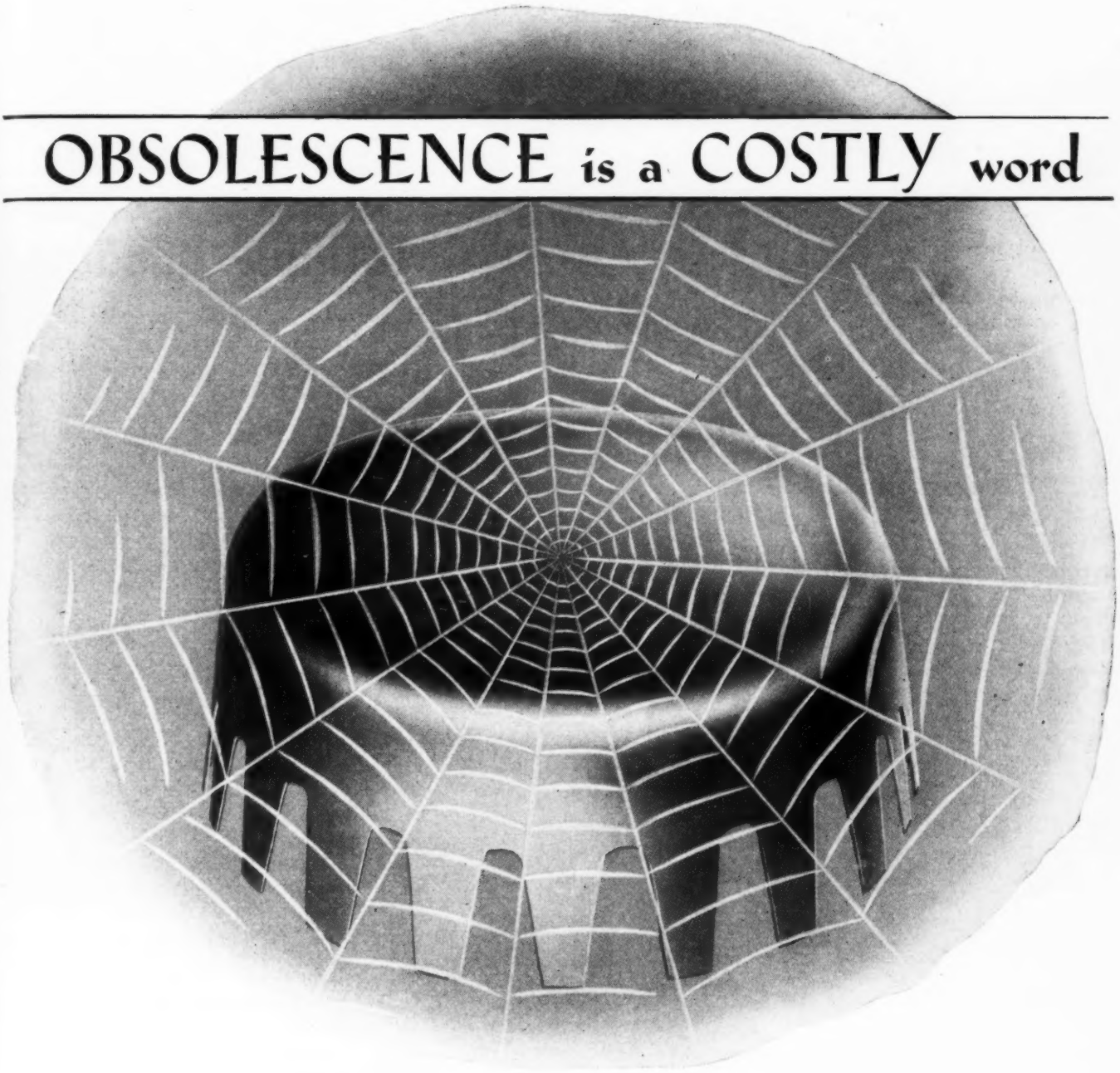
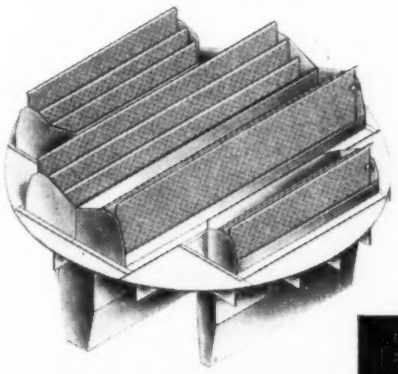
OBSOLESCENCE is a COSTLY word



This Koch Kaskade Tray is the first major development in fractionating trays in 30 years.



Compared to the ordinary bubble tray, the Koch Kaskade Fractionating Tray has up to 50% greater capacities and 25% better efficiency. Just two reasons why obsolete bubble trays are costing you a premium.

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What's Happening!

JUNE 1
1948

Summary of Current News Developments Concerning Oil Men

SYNTHETIC FUELS

Government subsidy of a commercial synthetic liquid fuels industry moved a step nearer reality May 12 when the House Commerce Committee unanimously approved a new version of the Wolverton bill (H.R. 5475). Bill is now before House Rules Committee, pending placement on the House calendar for action. Meanwhile, an identical companion bill (S. 2712) has been introduced in the Senate by Senator McCarran (D., Nev.) and referred to Senate Commerce Committee.

Revised Wolverton bill does not specify processes to be used, nor require that their selection be approved by the Secretary of Interior before Reconstruction Finance Corp. can make loans for private construction and operation of commercial synthesis plants. Interior can still step into the picture, however, a year or more after the proposed act is passed if it feels that private industry is not doing an adequate job, and direct RFC to construct and operate such plants as the Secretary of Interior deems necessary.

Government buying and selling of the output of synthetic liquid fuel plants, even at a loss if necessary, is also provided for in the amended bill. Another change provides for loans for research and development work, and for the construction and operation of pilot and demonstration plants, in addition to loans for the construction and operation of full-size commercial plants.

Instead of the $400,000,000 originally specified when the bill was first introduced, a limit of $350,000,000 has now been set on the aggregate amount of RFC funds which may be outstanding at any one time for carrying out the provisions of the bill.

• • •

EXPANSION

Socony-Vacuum is doubling capacity of its present 3000 b/d refinery at Casper, Wyo. New equipment being installed under general expansion program includes Thermofor Catalytic Cracking unit. Work is expected to be completed by next December.

Standard Oil Co. (Ohio) has upped by $5,000,000 its authorized expansion project at Lima, Ohio. In addition to $11,000,000 Fluid Catalytic Cracking unit now building, a new combination crude distillation and coking unit will be installed. Contractors for new project have not yet been selected, nor construction schedules mapped out.

Sun Oil Co. is planning to double its Toledo refinery capacity during next two years in an estimated $16,000,000 expansion program. Proposed additions will include a 30,000 b/d catalytic cracking plant (probably TCC), plus crude distillation, gas recovery and new polymerization units. Site clearing was expected to start June 1.

• • •

PETROCHEMICALS

Lion Oil Co. has started engineering work on additions to its anhydrous ammonia plant at El Dorado, Ark. Present capacity of 430 tons per day will be increased to 570 tons per day at a cost of $3,500,000. Project is scheduled for completion in spring of 1949, and will include pressure storage for some 4000 tons of ammonia.

Shell Chemical Corp. is building a new plant at Wood River, Ill., to manufacture an intermediate chemical used in making finished synthetic detergents. The unit will process raw materials received from the nearby refinery of its parent, Shell Oil Co. According to W. P. Gage, vice president, it may eventually be expanded to a complete plant for making petroleum-derived detergents.

• • •

SUPPLY and DEMAND

A new crude run record was chalked up last month. During the week ending May 15, crude runs to stills averaged 5,640,000 b/d, beating, even if by only 3000 b/d, the previous top figure of 5,637,000 b/d set in January. The industry continued to operate at from 95 to 96% of its rated capacity.

Crude production also climbed, reaching a new high of 5,439,200 b/d in the week ending May 22. A year ago just slightly over 5,000,000 b/d was being produced.

Demands can be met for gasoline and fuel oil during the coming winter and summer, Jersey Standard believes after an industry-wide survey conducted by the

Information on these pages is obtained through the nation-wide news coverage services of PLATT'S OILGRAM NEWS

company. A petroleum demand of 2.2 billion bbls. in 1948 will be met, the Jersey survey disclosed, by 2.15 billion bbls. of domestic production and 175 million bbls. of imports, which allows for some stock increase. Refinery capacity is adequate to handle a total of 2.2 billion bbl. demand — barring labor troubles, refinery fires, "sharp curtailment" of steel or other "catastrophes."

Indiana Standard also takes a bright view of the future supply-demand picture. Dr. Robert E. Wilson, chairman of the board, told the API Refining Division meeting in Philadelphia that an approximate 5% increase in supplies of petroleum products would be available for domestic consumption this year. He qualified his prediction, however, with four "Ifs"—if new oil burner installations return to relatively low prewar rate, if consumers continue to co-operate in conservation, if we have a moderate winter, and if there are no serious strikes in our or other basic industries.

• • •

TETRAETHYL LEAD

Price increases for TEL were announced May 10 by DuPont following similar increases made public the previous month by Ethyl Corp. Effective July 1, new prices for DuPont's TEL motor mix will be approximately 33.8c per lb., an increase of about 10%, while price of company's antiknock compound for aviation gasoline will be slightly under 37.2c per lb.

In releasing new prices, DuPont stated that rising costs for raw materials, manufacturing and transportation made the increases necessary. It cited as one example the increase in cost of metallic lead, now "particularly scarce throughout the world," from about 6c per lb. prewar to a minimum of 17c per lb. today.

Supply outlook for lead, meanwhile, brightened. According to figures furnished by the Lead Industries Assn., domestic lead production in 1948 will exceed 1947 production by 10%, perhaps 15%. Production in February of this year reached the highest daily level since May, 1945, and new exploration and development work is expected to boost present production even higher.

• • •

LABOR

Threats of a strike among 10,000 Sinclair Oil Corp. workers were averted last month when Sinclair and the Oil Workers International Union reached an agreement on wage increases. If ratified by union membership, almost a certainty, a net increase of 17.5c per hr. in the base wages of all employes in Sinclair's production, refining and pipe line operations will become effective July 1.

In addition, among other contract modifications, the former 10c an hr. cost of living bonus will be included in the base pay, double time will be paid for work on the six generally observed holidays with adjustments for workers on vacation on those days, and paid vacations for 25-year men will be increased to four weeks.

Other agreements reached last month in the refinery labor field:

Humble Oil & Refining Co.—Baytown Employees Federation, independent, accepted a compromise offer by the company calling for an increase of 12c an hr. in base pay and a $20 a month living allowance for an indefinite period. Federation had asked for 21.5c an hr. plus a cost of living bonus.

Esso Standard Oil Co.—All refinery and sales unions in company's six refineries and 12 sales districts accepted an offer of 12c an hr. increase in base rates. Offer was made in reply to union demands for wages increase varying from 20 to 30c an hr.

Socony-Vacuum Oil Co.—Net wage increase of 15c an hr. was contained in a contract signed by Socony's E. St. Louis refinery and Local 19119, Federal Labor Union (AFL).

• • o

TRANSITION

Delta Refining Co. at Memphis, Tenn., was taken over May 21 by Missouri Farmers Assn., a co-op. MFA presently owns an 1800 b/d refinery at Chanute, Kans., built in 1929. The newly-acquired Delta plant was built in 1941-42; rated capacity is 4500 b/d.

Max W. Ball, director of Interior Department's Oil and Gas Division, plans to return to private life sometime before Aug. 1.

• • •

MISCELLANY

To consolidate crude procurement needs, a group of Midwest refining companies have formed Refiners Service, Inc., with offices at present in Tulsa and Mt. Pleasant, Mich. Head of the new service company will be David Beach, until recently president of Leonard Pipe Line Co. of Michigan.

The longest recorded run for a Dubbs Thermal unit has been established at Sunray Oil Corp.'s refinery at Allen, Okla., according to F. L. Martin, executive vice president. The thermal cracker, a three-coil unit and the only one of its type in the U. S., was shut down for inspection and cleanout April 29 after being on stream 170 days, 22 hours. During that time it processed 1,373,675 bbls. of charging stock.

Fire totally destroyed one of several gasoline treating units at the El Segundo, Calif., refinery of California Standard April 26.

AMBASSADORS OF GOOD WILL

"Thanks for a very satisfactory job"

"Accept our extreme appreciation for the hearty cooperation your crews extended"

"I commend your erection crews for their ability, cooperation and general helpfulness"

AMBASSADORS

". . . we are reminded of the American 'tank gang' who were in our midst for so many months and who left last week for Saigon. These 'tank gangers' have done something; they have perhaps done more to establish good-will in the Far East than all other American contacts, diplomatic or commercial. They have, in truth, proved themselves worthy ambassadors of the great nation to which they belong". J. E. K.

Above comment entitled "Ambassadors" appeared in the South China Morning Post, November 16, 1947, after the HAMMOND IRON WORKS crew left for Saigon.

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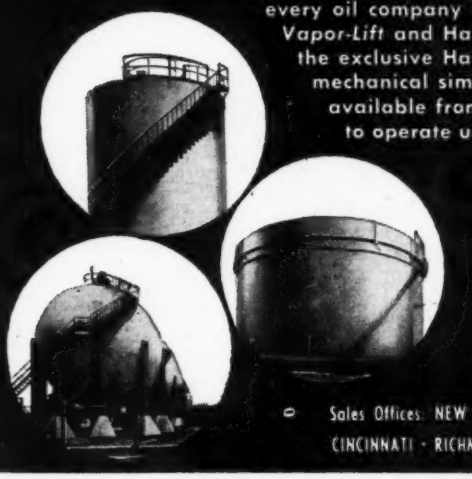

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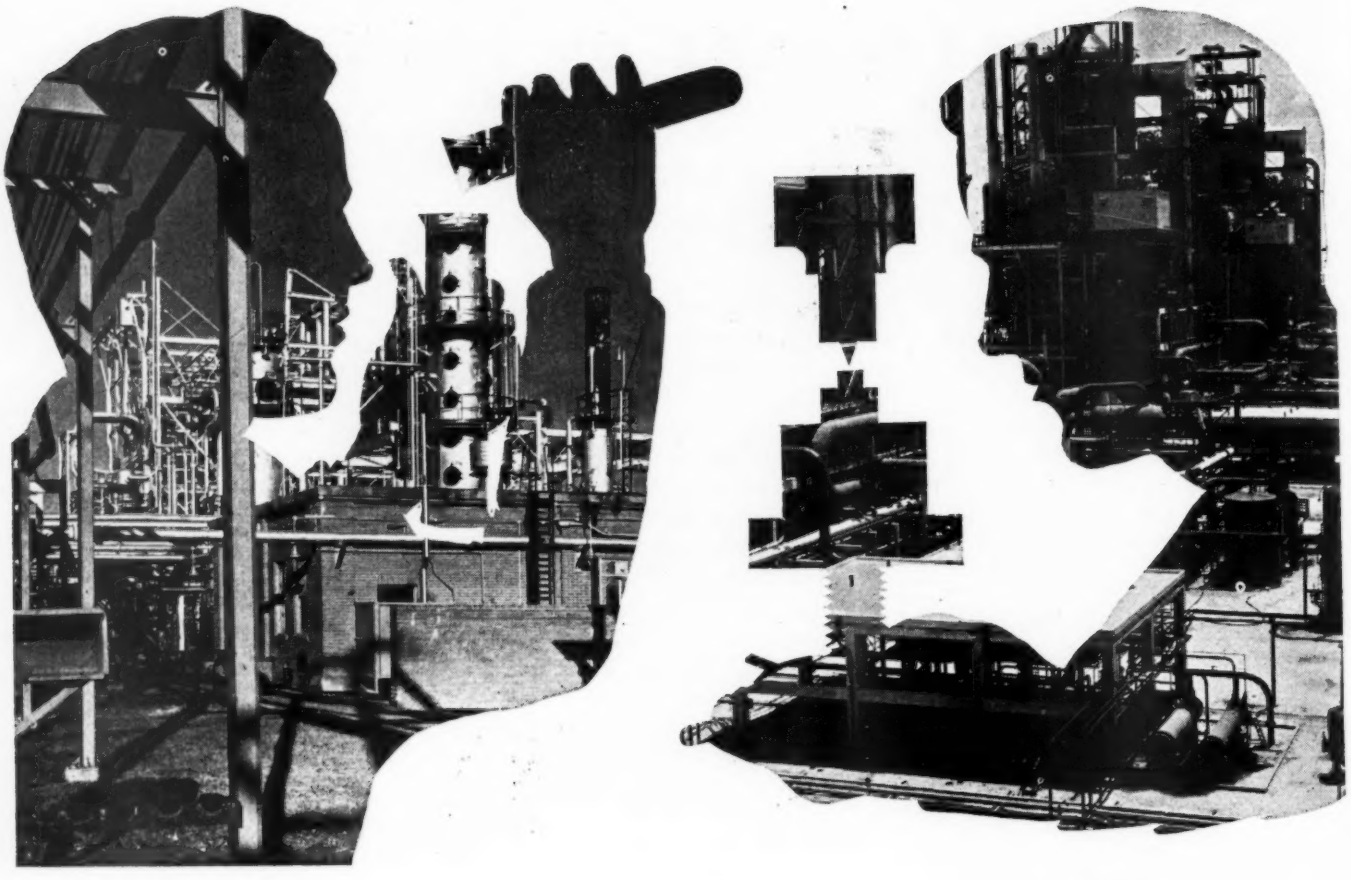

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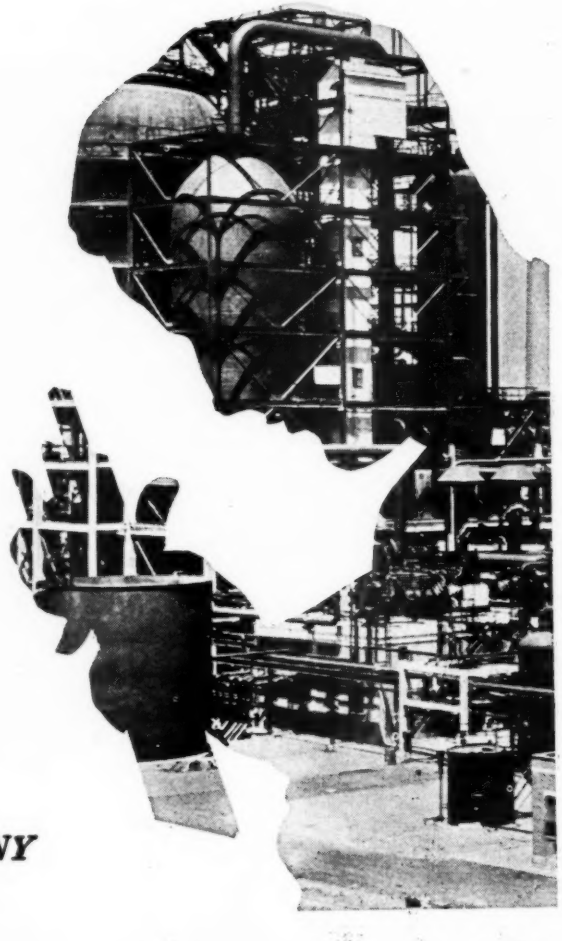

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TOMORROW

. . . IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Storage of natural gas as hydrate is suggested.**
- **"Punched Card" system for information data**
- **Aircraft gas turbine fuels and lubricants pose industry problem.**
- **Antifreeze supply still in question.**

Storage of Natural Gas Hydrate is Suggested

STORING NATURAL GAS in sufficient quantities to meet peak loads over long periods has long been one of the biggest problems facing areas far removed from producing fields or located in regions where production capacity is insufficient to meet demands. Various methods of solution have been attempted, including repressuring of nearby depleted fields (even oil fields), liquefaction of the gas, storage in insulated tanks, etc.

Study of a possible new means for storing gas was undertaken in 1946 by the Institute of Gas Technology, under the sponsorship of the American Gas Assn. and the results recently published as a research bulletin.(1)

According to E. S. Pettyjohn, director of the Institute, the prime purpose of the project was to report on the status of all work which has been performed on hydrate storage and to survey the pertinent patents from an engineering point of view. The current literature on hydrates of the paraffin hydrocarbons has been collected and critically evaluated, and "means of practicing the formation, storage, and subsequent regasification of hydrates of natural gases are suggested and discussed." Unfortunately, insufficient data are available for preliminary plant design, so that reliable cost estimates could not be included.

Space does not permit detailed discussion here of any of the many factors involved, as reported in the bulletin but some further concept of the subject may be gained from the "Conclusions" reached by Dr. Parent.(1)

"1. There is an inadequate amount of data available in the published literature to permit plant design. Further, many of the data available are not highly accurate. There is a great need for quantitative reaction data, and none are available as yet.

"2. Methane, ethane, propane, isobutane, and normal butane form hydrates. The higher paraffin hydrocarbons do not. The butanes in pure form do not react readily with water. None of the hydrocarbons react with ice at a measurable rate. Non-equilibrium conditions, particularly resistance to hydrate formation or decomposition, have been encountered.

"3. Additives such as alcohol have been reported which shift the equilibrium conditions for hydrate formation. In the cases observed the shift is in the direction of higher pressure for a given temperature. Such substances are useful for decomposing hydrate, and may prove to be of aid in its regasification.

"4. The process involving the formation of hydrocarbon hydrates from natural gas and water at times of low load followed by storage and subsequent regasification during the peak load season appears to warrant further investigation. More technical data are required before a reasonable economic analysis of the hydrate process can be made. Certain general suggestions can be made as to means of carrying out hydrate processes.

"5. Any hydrate process will have greater space, initial refrigeration and final regasification heat requirements than should characterize the liquefaction process.

"6. The temperature levels for hydration, storage and regasification are very favorable for the hydration process.

"7. The storage of natural gas as solid hydrate appears to be safer than as liquid."

Obviously, much will have to be learned before the economic potentialities of the "solid" storage of natural gas can be properly evaluated, but Conclusions 6 and 7 (above) are of some significance as a counterbalance to the unfavorable findings listed in Conclusion 5. Storage of natural gas in liquid form should not be "counted out" as a future method, despite the Cleveland disaster of 1944 but attention will certainly continue to be given to methods which are apparently safer.

"Punched Card" System For Information Data

AUTHORS OF ARTICLES in and readers of technical journals are interested, *per se,* in the provision and acquisition of information of present or potential value. In addition, they have in recent years become increasingly concerned with the location of available information when and as needed.

The petroleum industry has been particularly interested in this problem, and its librarians and information workers have contributed much to the development of the techniques employed by those charged with the task of providing information on demand. M. P. Doss of The Texas Co., D. F. Brown of the Standard Oil Development Co., and Gustav Egloff and his U. O. P. assistants are among the many whose presence may be taken for granted at such sessions as the Chemical Literature Group symposia held at recent American Chemical Society national meetings.

One problem which has provided almost the central theme of these latter meetings is the collection of information files in a readily usable manner with a minimum of effort and expense. Until recently, the only practical method seemed to involve reproduction of the desired material (abstracts, bibliographic data, etc.) on file cards or forms of appropriate size, a scheme which often necessitated the preparation of numerous duplicate cards if the data were to be filed under all the categories to which it pertained. Where funds, reproduction equipment, and storage space are adequate, this method still has much to offer, but it has obvious disadvantages for the individual who wants to keep his own files on a number of subjects, and even those organizations which have found it satisfactory are not blind to its failings.

For this reason, much attention in industrial and scientific circles has recently been focused on the use of "punched cards"—cards whose edges or other areas can be selectively punched in accordance with prearranged index systems so that, at a later date, they can be rapidly separated, by hand or machine, from other cards which do not relate to

(1) J. D. Parent, *The Storage of Natural Gas as Hydrate,* Institute of Gas Technology Bulletin No. 1, Chicago, 1948. 40 pages.

the subject on which information is sought.

It would be inappropriate here to consider the details and ramifications of this subject, but it certainly seems worthwhile to call attention to a recently-published bibliography[2] on the uses of punched cards, so that those interested further may have a definitive guide to the available information.

Aircraft Turbine Fuels and Lubricants Pose Problem

NO MATTER WHAT the size of the expansion of our military airforce, the provision of fuels and lubricants for it will be a problem placed squarely upon the petroleum industry, just as was the demand for 100-octane gasoline in the recent conflict. Hence all information which becomes available on aircraft gas turbine fuels and lubricants is being carefully scrutinized, so a recent review[3] of the technical factors, insofar as they are presently understood, is being read with interest, especially by those companies and individuals not already actively engaged in work in this field.

As stated in this review, the properties which are of significance in gas turbine fuels are: (1) volatility, which "should be selected on the basis of starting safety, combustion, smoke, deposits, and availability," (2) vapor pressure, which "involves considerations of vapor handling capacity of a given fuel system and fuel evaporation," (3) chemical composition, important because the fuel must "provide proper combustion and rapid burning," (4) heating value—"the highest heating value (per unit volume) is desired, provided it is not at the expense of other factors," (5) stability or gum tests, which "will be required according to length and conditions of storage," and (6) low freezing point, "lower than minimum anticipated atmospheric temperature."

Few of these factors can be discussed here in any detail. Volatility characteristics indicate the need for kerosine type fuels instead of gasolines if serious vapor losses are to be avoided. In regard to chemical composition, it would appear that "paraffinic and naphthenic fuels are easier to burn than a highly aromatic type made from cracked stocks." However, "the general feeling is that fuels containing aromatics up to 30% may be satisfactory," although more data are needed on this point, also on the behavior of olefins.

The poorer combustion properties of aromatics are unfortunate from the point of view of heating value, since an aromatic kerosine contains 17.5% more Btu, per gallon than 100/130 aviation gasoline, while a paraffinic kerosine contains only 11% more Btu than this gasoline (naphthenic kerosine, 14% more). "Since the latest models of aircraft are becoming volume limited—i.e., less space is available for fuel tanks as a result of thinner wings, higher wing loading, and smaller fuselage—it appears that selecting a fuel of the highest Btu per gallon is desirable."

Preliminary gum studies indicate that cracked stocks can be used only in limited quantities if at all, although straight-run stocks present no problems.

The problem of availability is obviously of the greatest importance. An industry study has indicated that the present JP-1 (AN-F-32) grade of jet fuel, "essentially kerosine," can be produced from crude oil in only 6% yields. "Freezing point and viscosity requirements appear to be the most restrictive requirements." The recently-proposed JP-3 fuel, however, could be produced in yields of 30-35% from straight-run stocks, or 55% if cracked stocks could be employed; "the principal change from JP-1 to the JP-3 grade is a much wider distillation range which has been increased to approximately 100 to 600° F. . . . The JP-3 grade, based upon data already obtained, should show satisfactory performance in the engine from the standpoint of good low temperature starting, combustion efficiency, smoke, and deposits."

As regards lubricants, turbojets "will operate satisfactorily on light lubricating oils," while propjets "require higher viscosity oils for lubrication of highly loaded propeller reduction gears."

The events of the next few months and years will reveal whether or not demands for aircraft gas turbine fuel can be met by the petroleum industry. Since the industry most certainly does not want increased government control, it can be expected to exert every effort to meet these needs entirely through its own efforts.

Antifreeze Supply Still in Question

DESPITE VASTLY increased production of base materials, there still appears some question as to whether sufficient supplies of antifreezes will be available next winter to meet all demands. While the permanent type antifreeze plant of the Jefferson Chemical Co. is now in full operation, and other plant additions and new producers are expected to push capacity next year to 150% of that existing in 1947, rising demands for other uses of glycols, coupled with high prices (as compared with methanol) and still-insufficient capacity, will probably prevent the glycol antifreezes from providing for more than one third of antifreeze demand during the coming season.

Methanol, however, will be available in larger quantities, because of recent plant completions and the conversion of certain wartime ammonia units. In fact, "one manufacturer-seller of the three types of antifreeze believes he will have sufficient methanol to meet sales requirements for nonpermanent type and plans to sell it in preference to alcohol, but his price for methanol has been increased from $1 to $1.25 per gallon. He thinks 10% of the total antifreeze market will be (ethyl) alcohol and anticipates keen competition for that 10%.[4]

Incidentally, it is said[4] that Carbide and Carbon is now offering a new grade of Prestone, whose changed inhibitors, hence changed specific gravity, have made obsolete present testers for Prestone antifreeze solutions. More significant than this filling station problem, however, is the reason which may be behind this change, which "was said to be necessary to make it more suitable for present cars with high compression motors." According to other sources, engine tests on high-compression motors protected with glycol antifreezes are said to have revealed that such antifreezes raise the octane number requirements of the gasolines employed by 3 or 4 octane numbers, a serious matter in these days of tight supplies and increased cost per octane number increment.

Carbide and Carbon's new blend may be designed to overcome this problem, which, if true, would otherwise severely restrict future use of glycol antifreezes. Much of the above is rumor and should be accepted only in this light; however, the sources of the information in question are usually reliable, and Carbide's action is certainly significant. Incidentally, "so far as is known, no other manufacturers of permanent antifreeze have changed their formulas."[4]

Antifreezes are of considerable importance to an industry interested in keeping all possible gasoline-consuming cars in constant operation. It can therefore be anticipated that petroleum companies will exert every effort to obtain adequate supplies of antifreezes for their customers. This should become increasingly easy in future years unless war comes again.

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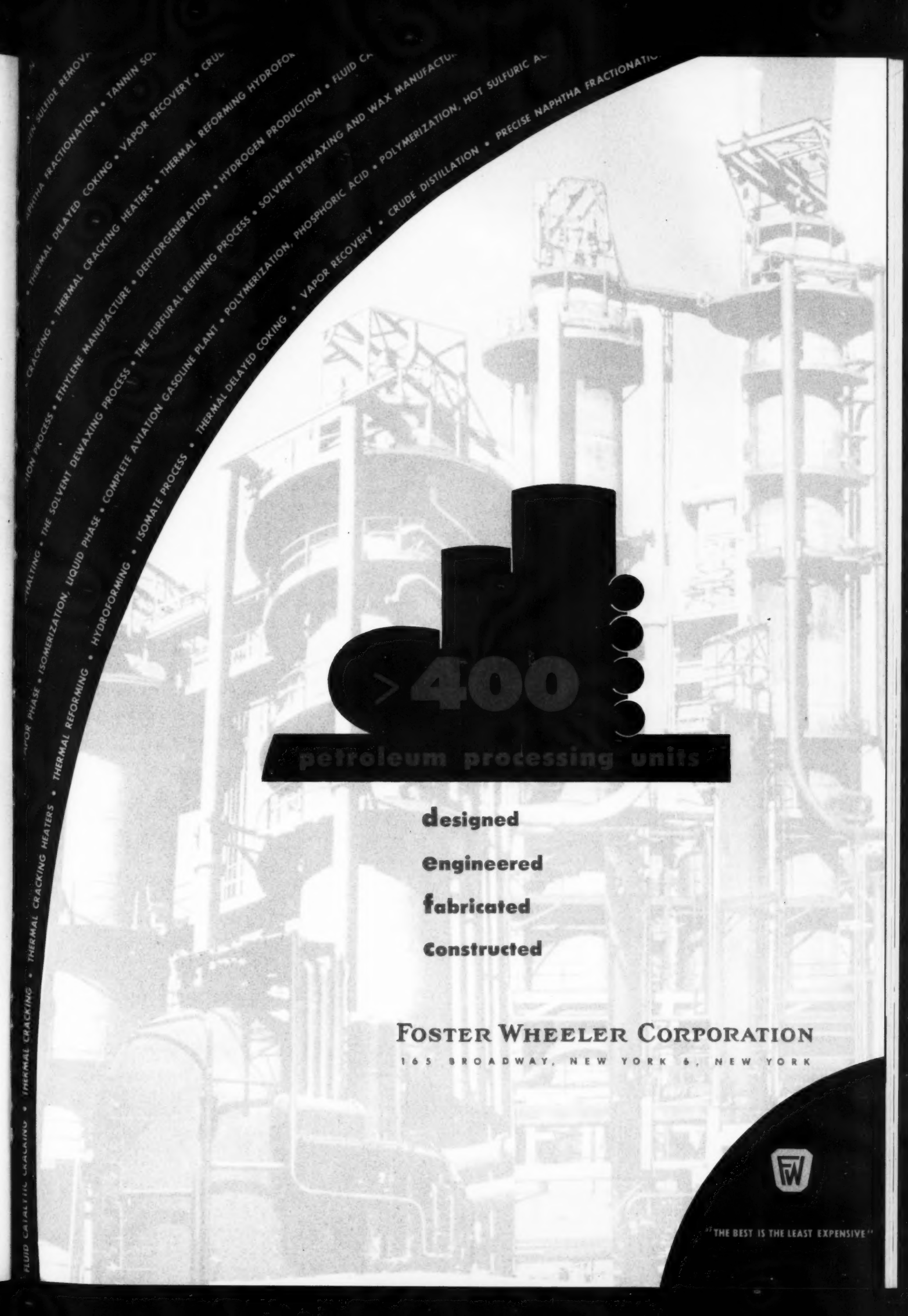
(2) L. Ferris, K. Taylor, and J. W. Perry, *Bibliography on the Uses of Punched Cards*, American Chemical Society Mimeographed Bibliography, Washington, 1948. 27 pages.

(3) Anon., "Aircraft Gas Turbine Fuels and Lubricants," *Lubrication* 34, No. 4, 37-48 (1948).

(4) Earl Lamm, "Oil Companies Push TBA Sales With An Eye on 'Gas' Supply," National Petroleum News 40, No. 16, 7, 9 (1948).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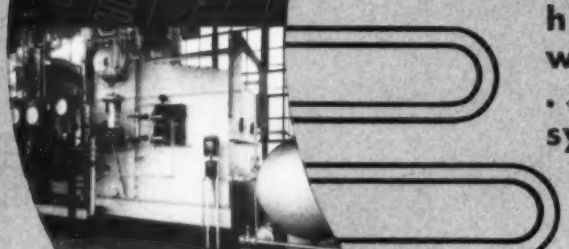

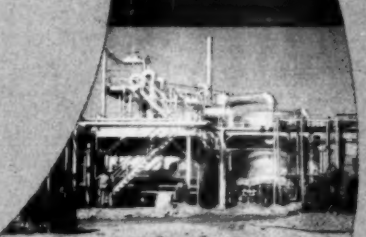

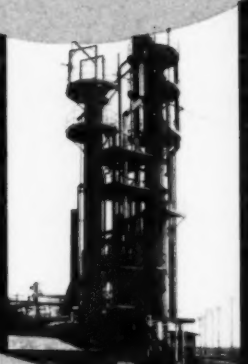

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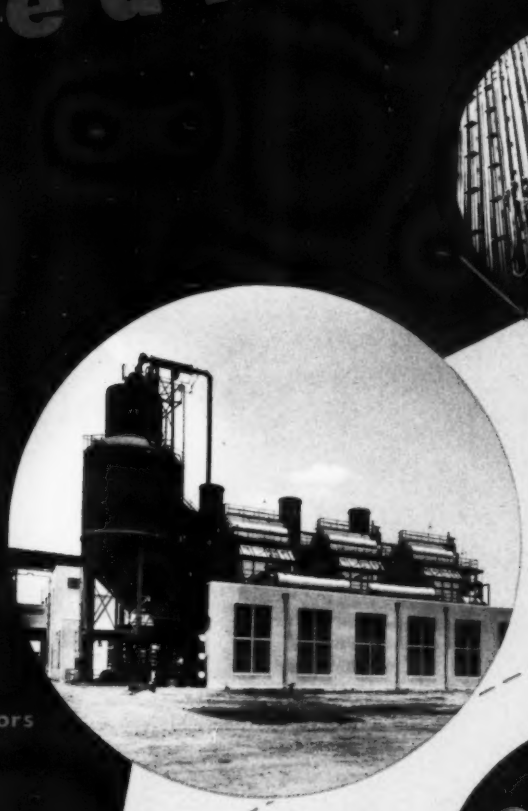

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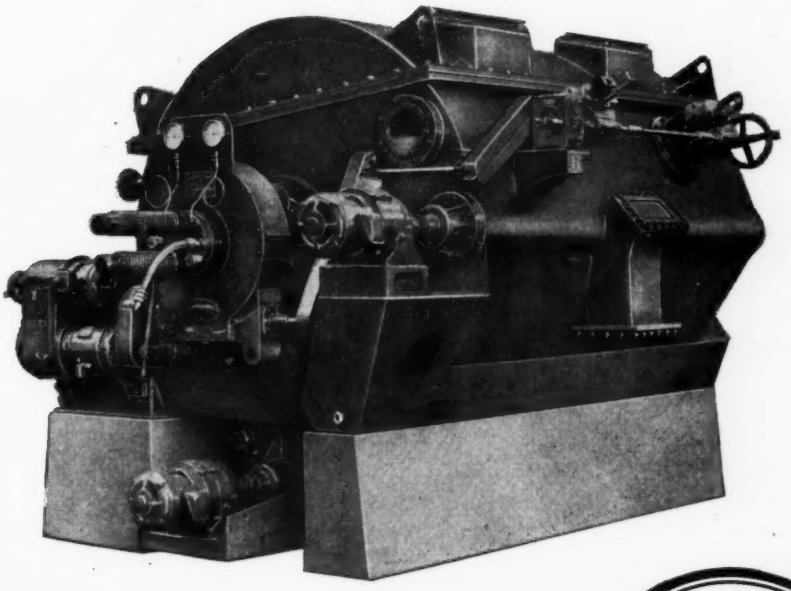

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REFINERS' TOOLS and MATERIALS For TOMORROW'S GASOLINE

PRESENT facilities available to refiners for improving their motor gasoline production were reviewed at the 13th Mid-Year Meeting of the American Petroleum Institute Division of Refining, in Philadelphia, May 11-13. The emphasis was on achieving larger yields, to meet present volume demand, rather than on making higher quality products.

Experience in combatting corrosion of refinery equipment was also featured on the program, and one session was given over to papers and discussion of methods for the organized training of refinery workers.

Unfortunately, as far as refiners taking complete advantage of suggestions for improving yields is concerned, changes in design of fuel systems of cars are required which can only be developed over a period of time and with the cooperation of the automotive industry.

The most readily available means for refiners to increase the volume of motor gasolines they produce, without processing additional crude, is to utilize more butanes, the overall supply of which is rapidly increasing, particularly natural-gas butane.

The big IF to inclusion of more butane as such in gasoline is in the present generally accepted vapor pressure limits for motor fuels. If higher vapor pressure fuels are marketed, evaporation losses from present equipment would run higher in the storage and handling of such fuels, from the refinery through to the vehicle carburetor. Also, as was pointed out, utilization of significantly higher vapor pressure fuels might require designing car fuel systems to provide lower operating temperatures in carburetors and with other means to avoid bringing back the vapor lock problem.

However, and despite these and other limiting factors, the problem of the utilization of butanes by refiners will fast become more critical through abundance of the supplies, the API meeting was told. Impressive data was presented to bear out this conclusion. While the production of natural-gas butane in 1946 was slightly under 10% of motor fuel yield from crude, the reserves of natural-gas butane amount to over 30% of the motor fuel in the crude oil reserves at the 1946 yield of motor fuel from crude.

Present potentially available butane for the entire industry amounts to 153,000,000 barrels annually, it was brought out, of which considerably less than a third is utilized for blending in motor fuels and another third of which is not reduced to possession. More than a third is used as LPG, chemical raw materials and the synthesis of fuels by such refining processes as catalytic and thermal polymerization and alkylation.

"All solutions of the butane problem other than motor fuel blending evade the issue", said one authority in summing up a detailed study of present and future supplies of this material. "The butane problem has been growing more acute and, if certain petroleum-industry trends continue, it may become of tremendous magnitude."

Improvement in automotive fuel systems to provide satisfactory operation with fuels of only 1 lb. more in Reid vapor pressure would have permitted the inclusion of 9,700,000 bbl. more of butane, which is equivalent to 21,700,000 bbls. of crude at the 1946 gasoline-yield ratio, said this same authority.

"Thus the failure to take this relatively small step required 4½ days' extra crude supply and refinery operation in 1946", he said. "It is interesting to speculate on what could have been done about the burner-oil shortages with 4½ extra days of refinery operation". The above quotations are from the paper, "Natural-Gas Butane and Motor-Fuel Vapor Pressures", by R. G. Alden and T. W. Legatski, of Phillips Petroleum Co., and presented by the former (a review of which appears in this issue beginning on page 579).

With the current interest in conservation in mind, an evaluation of the utilization of butane-butylene

Papers Reviewed

Reviews of some of the individual papers presented at the meeting of the API Refining Division in Philadelphia, May 11-13, are published in this issue, grouped by subjects as follows:

Corrosion ..... pg. 549
Training ..... pg. 556
High Octane Fuels .... pg. 565
Butane Utilization ..... pg. 573

fractions, both by conversion into liquid products and by direct blending into motor gasoline was presented from the standpoint of overall potential energy recovery. This was based on a study in the Research and Development Department, Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

The energy, in reactants and fuel and utilities, required to operate alkylation, and catalytic and thermal polymerization, was compared with the energy content of their products, Btu per gallon of gasoline produced. For example, the study showed that 144,000 Btu per gallon of gasoline produced were required to operate the alkylation process and the energy content of the gasoline produced was 112,000 Btu. per gallon. The efficiency of the process on an energy basis was taken as the energy content of the product divided by the total energy required to operate the process.

For alkylation, the energy efficiency arrived at was 78, with a corresponding energy loss of 22%. Energy losses for catalytic and thermal polymerization, similarly arrived at, were 18 and 21% respectively.

Where butane is directly blended into motor fuel, it was recognized that increased evaporation losses in the storage and handling of the product would be encountered, the rate of increase depending on the vapor pressure of the motor fuel product. Such evaporation losses were studied for a typical company manufacturing gasoline on the Gulf Coast, transporting to the East Coast in tankers and with a sequence of 13 storage and handling operations taking place from the refinery through storage in the service station tank.

Three types of evaporation losses which occur between the service station and the car engine were recognized as loss in filling the car tank, loss from the car tank in driving and non-driving periods and loss from the carburetor bowl during driving periods. The losses from this total of 16 operations from the refinery through the carburetor bowl were estimated in per cent volume for 8, 10, 12, 14 and 16 RVP gasoline, for summer, intermediate and winter temperatures. Losses in per cent volume of incremental butane for the various RVP fuels were also estimated.

The total evaporation loss of the incremental butane from the 16 operations was placed at 64 vol. % for 10-lb. RVP gasoline for summer temperatures; 52 vol. % for 12-lb. gasoline for intermediate temperatures, and 38 vol. % for 14-lb. gasoline for winter temperatures.

"In comparing methods of utilizing butanes, some allowances have to be made for the natural resources other than petroleum necessary to convert butanes into gasoline by alkylation or polymerization. Appreciable amounts of steel, concrete, chemicals, and manpower are required to construct and operate these conversion plants.

"From the standpoint of the overall conservation of natural resources, higher energy losses can, therefore, be tolerated when excess butanes are included directly in gasoline than when they are chemically converted to gasoline. The difference in losses between the two procedures that exist at the break-even point is extremely difficult to evaluate."

The conclusion of this study was that, when all the evaporation losses in gasoline operations from manufacturing to ultimate use are considered, higher energy recoveries could be made by converting excess butanes to gasoline by chemical means than by direct inclusion of them in gasoline.

However, if only the losses occurring from manufacture to the purchase of the gasoline by the consumer are considered, the situation is reversed.

Principal speaker at the dinner session during the API Refining Division meeting in Philadelphia was James Terry Duce (left), of Arabian-American Oil Co., who talked about "Tommorrow's Oil." Standing behind him is Robert E. Wilson, API's vice president for refining and chairman of the board for Indiana Standard

The above is from the paper, "Problems in the Efficient Utilization of Refinery Butanes" by T. L. Apjohn and D. P. Heath, of Socony-Vacuum's Research and Development Department, and presented by Mr. Apjohn. (A major portion of the paper appears in this issue, beginning on page 573).

When the refiner processes for high-octane motor fuels, he reduces the volume of his base gasoline approximately 1% for each octane number improvement, L. L. Davis, Continental Oil Co., Ponca City, Okla., brought out in his paper, "Front End Volatility as It Affects Processing of High-Octane Number Fuels". (A major portion of which appears in this issue, beginning on page 565). At the same time the amount of surplus refinery butane is increased rapidly with increase in octane number. "The

amount of natural gasoline and butane the refiner may use in the current low-vapor-pressure fuels approaches the vanishing point, with further reduction in available motor gasoline", he stated.

The most economic solution of this problem, it was brought out, would be through improvement in the ability of engines to use high-vapor-pressure fuels. Such fuels could be provided by refiners in both increased volume and octane number and the loss in volume of base gasoline for the same blended octane number would be decreased. "An increase in summer vapor-pressure tolerance from 8 to 12 lbs. would increase production by 10 to 11%, thus more than offsetting the volume loss which will occur with octane number increase of 10 points," Mr. Davis stated.

This paper also considered what refiners might be able to do on their own behalf, to offset this loss in volume when processing for high octane numbers, with the accompanying increase in production of butane.

"As equipment becomes available and economics permit, the refiner may materially improve the volume-to-octane relationship by installing more highly specialized processes", the paper brought out. "These may include (a) hydroformation, or cyclization and isomerization in place of naphtha reforming, (b) alkylation instead of polymerization both to increase rich blending stock and decrease surplus butane, (c) butane isomerization and possible dehydrogenation, for increased alkylate production. and (d) hydrogenation, either destructive or for the improvement of isoolefins."

At the other end of the distillation scale, material gains in yields of catalytically cracked gasoline are possible through raising tail-end boiling points, it was brought out in a paper entitled, "The Factor of Gasoline Tail-End Volatility", prepared by J. Bennett Hill and Walter C. Huffman, of Sun Oil Co., Marcus Hook, and presented by Dr. Hill. (The paper is reviewed in this issue, beginning on page 567).

In the decade preceding the war the trend in tail-end boiling points was downward due to the necessity for refiners to undercut their gasoline components both from straight-run towers and from thermal cracking plants to secure a product of the desired octane number. This trend was taken advantage of by the automobile industry in the design of their intake systems.

With catalytic cracking, however, it was pointed out there is substantially no decrease in octane number in the higher-boiling fractions and the sound economic consideration for the refiner is to incorporate the heavier catalytic fractions into his motor gasoline. The net results of this practice are to raise the tail-end boiling points of the gasoline delivered to the customer, which may interfere with the warm-up and other performance characteristics of the fuel at temperatures of freezing and below.

For a projected 100,000-bbl. refinery including crude distillation, thermal reforming and thermal cracking, catalytic cracking, vapor recovery, catalytic polymerization, and alkylation it was shown that the total change from cutting the catalytic gasoline stream from 90% at 360° F. to 90% at 430° F. results in 2600 bbl. more gasoline, or an increase of 2.6% in the gasoline output of the refinery.

"If this volume increase is based back on the volume of catalytic gasoline," the paper stated, "the per cent increase is substantially independent of the concentration of catalytic cracking capacity in the refinery and may, therefore, be applied to the country as a whole. Let us assume that the total catalytic charging capacity of the country is 1,200,000 b/d and that average practice gives a catalytic gasoline yield of 42% of product with a 90% point of 370° F. This would mean 504,000 b/d of catalytic gasoline of this quality.

"Compared with this, the yield of catalytic gasoline with a 90% point of 430° F. would be about 577,000 b/d and, taking all things into consideration and keeping octane number constant, the total gasoline production of the country from the same crude would be increased by 50,000 bbl. per day. With a 43% average yield of gasoline from crude, this corresponds to a saving of 115,000 bbl. per day of crude."

The answer to the question of using a gasoline of higher tail-end volatility seems to lie with the automobile industry, the paper concluded. The potential gain in gasoline output must of course, be balanced against the possible economic losses which might accrue if cars were designed for this heavier type of fuel.

The average butane content of the total motor gasoline produced by Standard Oil Co. (New Jersey) domestic affiliates during the winter time is about 10% or 22,000 b/d of butane, H. R. Poland, of Esso Standard Oil Co., New York, stated in his paper, "The Butane Problem as Viewed by an Integrated Refiner." During the summer time the average butane content is about 3.6%, or 8000 b/d. Problems occasioned by the seasonal variations differ according to the refinery location.

As a possible solution of handling the excess of butanes produced during the summer, Mr. Poland said the company in the past had stored butanes both in refrigerated tankage and in spheres. Each method has advantages depending on the local situation involved, he stated.

Methods available with present refining facilities for producing high-octane gasolines were reviewed, particularly from the point of view of their application by smaller refiners, in a paper, "Refinery Tools for Producing High Octane Gasolines," prepared by T. B. Kimball and J. A. Scott, Sinclair Refining Co., New York, and presented by Mr. Kimball.

The advantages of improved straight-run fractionation and reforming were emphasized, and the use of polyforming in place of thermal reforming. The effect of replacing thermal cracking with catalytic cracking of the heavier fractions of the crude was discussed. Supplementing of catalytic cracking with thermal cracking of the catalytic cycle stocks for maximum yield of high octane gasoline was suggested.

The alternate use of catalytic polymerization vs. alkylation for processing of propane and butylene fractions is reviewed. In general, the increases in yields shown possible can only be accomplished at increased costs, the paper points out. (Note—This paper will be published in the July issue of PETROLEUM PROCESSING.)

Alloys for Corrosion

Extensive data on the use of inhibitors and neutralizing agents and on the careful selection of materials of construction for preventing corrosion in refinery equipment was brought out in three papers at the API meeting representing the experience of three different refineries.

In the absence of economical means for the removal or neutralization of corrosive materials in the crude oil, the use of alloys will continue to be economically attractive, M. A. Furth, Pure Oil Co., Nederland, Texas, stated in his paper "Prevention of Corrosion in Refinery Heat-Exchanger Equipment." Protection of this type equipment in a plant processing three types of crudes—sweet, East Texas, and Louisiana—was discussed in the paper. (A major portion of the paper is published in this issue beginning on page 549.)

"The development of new alloys must be followed in the interest of keeping material costs to a minimum consistent with required service life," Mr. Furth concluded. "Careful consideration of service conditions and proper material specifications will substantially reduce the petroleum refiner's heat-exchanger corrosion problems."

Because the application of alloys is necessarily expensive, Pure Oil's experience has indicated a number of factors helpful in determining the

extent of application. Two factors cited by Mr. Furth are:

"1. Importance to operations: In corrosive services, where the continuity of operation of a process unit depends upon a particular exchanger, the use of corrosion-resistant alloys is almost mandatory.

"In services where an exchanger is not a vital link in the process but, nevertheless, is important from a heat-conservation viewpoint, economics may favor alloys which will assure continuity of service.

"2. Maintenance costs: Excessive maintenance charges will result from frequent retubing or replacement of parts. Higher priced alloys which render longer service life can frequently be justified on the basis of reduced maintenance costs."

Combined Attack

A combination attack on the corrosion problem seems advisable according to E. N. Salathe, chief engineer, Standard Oil Co. (Ohio), in his paper, "A Resume of Sohio's Experience in Overhead Condensing Equipment." Careful development of the proper alloys is coupled with careful maintenance of the proper pH through neutralizing chemicals in Sohio's Cleveland refinery. (A review of this paper appears in this issue beginning on page 555.)

Among interesting methods brought out by Mr. Salathe is the use of cathodic protection devices to prevent corrosion in open-box condensers. The difficulties in such equipment, Sohio engineers have felt, are largely dependent on galvanic action between the cooling coil and the sides of the box. A limited number of installations of cathodic protection devices about four years ago has brought satisfactory results, it was said.

Corrosion in crude still overhead condensers has been remedied to some extent by regulating the pH of the system. This is accomplished by withdrawing a continuous sample of the aqueous condensate from the reflux accumulator of each still and determining the hydrogen-ion concentration by a pH recorder. Control is then made by injections of ammonia, using rotameters.

Neutralizing Agents

Considerable merit is to be found in the greater use of chemical protection for refinery equipment, it was stated in a paper, "The Use of Chemicals for Retarding Corrosion," by H. L. Bedell, Socony-Vacuum Oil Co., Augusta, Kans. However, the author emphasized that corrosion has not been stopped in the refinery by either the use of chemicals or the use of alloys. Much of the work done so far, it is indicated, has been experimental. Of necessity, it must tend to remain so, because continual change in operating conditions and charge stock change the corrosion protection needs.

"The greater use of chemical protection neutralizes many acid conditions," Mr. Bedell stated, "not only for the crude units, but also for the succeeding stills, gasoline-recovery plants, and other equipment. Alloy parts for pumps, towers, lines, valves, etc., for all these units would be prohibitive in cost or not readily obtainable."

Conventional commercial chemical treatments are all being used, and include 76% sodium hydroxide and ammonia of 29° Baume, both of which are diluted before injection, and also lime in the form of a slurry. Cost of ammonia and caustic for all applications in the refinery, including the materials and handling charges, amounts to approximately $50 per day when 23,000 bbl. of crude are processed, it was reported.

Refinery Training Programs

The use of organized training programs to increase the efficiency of refinery operating and maintenance staffs was discussed in one session during the Philadelphia API meeting, and the intense interest in this subject now apparent among most refiners was evidenced by the barrage of questions which followed each paper. Most of the questions were aimed at finding out details of how the other fellow had met particular problems in setting up his own program.

First step in establishing an organized training activity, it was brought out by A. H. Houseknecht of the Training Division of Esso Standard Oil Co., is to determine just what training needs exist among the personnel.

"The primary reason for investing time and money in a refinery training program," Mr. Houseknecht explained, "is to bring about improvement in the performance of the work force. It therefore follows that, in advance of setting up any program, a definite need for improvement should be identified and interpreted in terms of the nature of training required . . . Only after specific training needs are known can effective and economical training be organized."

Mr. Houseknecht then went on to describe in his paper "Determining Refinery Training Needs" (reviewed in this issue, page 563) the procedure followed by Esso Standard in establishing its own programs.

"The study of training needs in the refinery never cease," he stated in his conclusion. "It goes on before, during and after the establishment of a training program in order to keep pace with the changing situations. This study should be systematic, and at the same time informal and continuous, rather than formal and periodic. In this way, training can be currently geared to the needs of the work force and produce the fullest benefit to our employees and to our business."

Actual first-hand experiences in putting a training plan into effect were described by another Esso man, W. J. McClintock, general superintendent of Esso's Baltimore refinery, in a paper "Experiences in Establishing Organized Training Programs."

One of the points brought out by Mr. McClintock was the need for a full-time training supervisor to head up such a program. "We recognized that we required a qualified training man to guide and assist us," he stated. "We needed a man who had a good background in training industrial people and the ability to 'fit in' as an accepted member of our working family.

"We arrived at this conclusion for the reason that in looking back over the years we had a good suspicion that in the process of improving the performance of our employes we had fallen far behind our technical advancement. Job training had depended upon each supervisor's knowledge and experience, and by and large was confined to enabling employes to do only the job at hand. It was evident that the continuation of this method of training would not satisfy our present and future operating needs."

A case history of the training experiences of Socony-Vacuum Oil Co. at its East St. Louis, Ill., refinery was given by H. A. Lutz and C. P. Baker in their paper "Training of Process Operators" (reviewed in this issue, page 556).

The Socony-Vacuum program included the setting up of written operating standards for stabilized refinery operations, with established points of control and descriptions of the methods to be used to maintain these points. These standards have been incorporated into operating manuals for the various units, with each manual also containing a general description of the unit, detailed operating instructions for specific pieces of equipment, and practical theory of operations.

As one illustration of the value of these manuals and established standards in stabilizing operations, the authors pointed out that prior to their use the 90% point of straight-run gasoline varied more than 20° F. from day to day. Following the establishment of standards and the proper training of operators, the 90% point varied less than 6°.

Gasoline and Cycling Plant Operations

Conducted by DAVE THORNTON

Petroleum Processing, with the cooperation of members of the Natural Gasoline Supply Mens Assn., is introducing this feature as a practical means to present helpful information on current problems to operators of natural gasoline and cycling plants. Authorities with the equipment and engineering companies of the supply association, among others, will furnish data to aid in answering questions presented. Readers are invited to contribute questions on operating problems in their own work.

Is cathodic protection of structures resting on or buried in the ground practical for natural gasoline plants? If so, under what conditions?

Yes, it is practical when evidence indicates galvanic corrosion is attacking tanks and buried lines.

The type of protection used—rectifier or metal anodes—depends on the structures to be protected, whether they are bare or coated, and the amount of current necessary. Actual costs cannot be generally stated unless a specific plant or condition is considered. However, it usually is presumed that the plant will have at least a ten-year life expectancy to make protection economically feasible; five years if located in "hotter," or lower-than-average resistance soils.

If the plant has uncoated lines in a relatively concentrated area, it is probable that rectified power from the plant electric lines will prove less expensive than the use of magnesium anodes because electric power will be relatively cheap and current requirements high. If the lines are coated, thereby requiring less protecting current, it is likely that magnesium anode protection will show up more favorably than rectification despite cheap power, due to the fact that magnesium anodes require no maintenance after installation and the amount of sacrificial metal required will be relatively small by reason of the insulating effect of the pipe coating. A similar situation exists in the refinery, where lines usually are bare and amount of surface involved is relatively great; high current drain off is required.

In general, sacrificial metal anodes prove most practical where current drains of up to five or ten amperes are required and a multiple current distribution system may be used. Where higher currents (up to 50 amp.) are necessary, rectification of AC power is more practical, even though periodic maintenance will be needed for the equipment. On pipelines, or at isolated locations where commercial power is not available and maintenance expense would be high, it is most practical to use magnesium anodes in a multiple distribution system rather than string power lines and install rectifiers.—E. P. Doremus, Cathodic Protection Service.

What are the uses and advantages of exhaust gas pyrometers on gas engines?

When exhaust temperature indicators are provided, the temperatures of the individual cylinder exhausts can be used in balancing the load equally between the cylinders of those engines provided with means of making such an adjustment. A faulty spark plug can be located quickly with the pyrometer.

Pyrometer readings can be misinterpreted easily, however. Often an increase in exhaust temperature from one or more cylinders is thought to be due to an increase in gas entering those cylinders with the high reading. A deposit of carbon in the cylinder ports will cause a restriction in the flow of scavenging air to that cylinder, causing high exhaust temperatures due to the cylinder getting insufficient air for proper combustion.

Unless this condition is realized, the operator may continue to adjust the gas to this cylinder, reducing it as the exhaust temperature increases until the cylinder ports have become seriously restricted. The result will be that the cylinder in question will become sufficiently unloaded to seriously overload the remaining cylinders. If any cylinder continues to have a gradually increasing exhaust temperature, it is advisable to check the peak cylinder pressure with a pressure indicator. Should the peak pressure be less in the cylinder in question than in others, the cylinder head should be removed and the carbon cleaned from the ports.—D. L. Gallogly, Cooper-Bessemer Corp.

How can "recycling" of air in a mechanical draft cooling tower be prevented?

The term "recycling" means the recirculation of hot, humid exhaust air from the discharge side of the cooling tower back into the air intakes. This recycling artificially raises the wet bulb temperature of the air, which in turn raises the cold water temperature in the tower.

The problem, then, is to prevent the hot, humid exhaust air from entering the cold air intakes. Recycling is a function of tower design and tower location. In general, forced draft towers recycle more than induced draft towers. The reason for this is that exhaust vapors leaving the forced draft tower, travel at such low velocities that a cross wind will cause them to be drawn back into the fan suction on the leeward side. In an induced draft tower exhaust air leaves at a rather high velocity, and the tendency to recycle is reduced.

The amount of recycling on an induced draft tower is primarily a function of the length of the tower, and the vertical distance between the top of the air intake louvers and the top of the fan stack. Recycling is of little consequence on an induced draft tower of two or three cells but it may become a serious problem on a tower with 15 or 20 cells.

The problem of getting dry air into the air intakes on the leeward side of a tower of 15 to 20 cells is a difficult one. This is because as wind blows across an obstruction such as a cooling tower, a turbulence is created on the leeward side causing the upper air to mix with the ground air. Air intakes on the leeward side of the center cells must draw their air from this mixture of ground air and exhaust air from the fans. The greater the distance from the top of the air intake louvers to the top of the fan stack the less recycling occurs. The greater the height of the fan stack the less the recycling effect. The wider the tower the greater the recycling effect. Little or no recyling would be expected from a tower of not more than 5 or 6 cells in which there is 25 to 30 ft. vertical distance between the top air intake louver and the fan deck, and a fan stack about 16 ft. high in which the discharge air velocity is about 2000 ft. per minute.

Recycling, as pointed out before, is a function of tower location. Buildings, columns, and other obstructions all have a detrimental effect on tower performance when located adjacent to a cooling tower. When a cooling tower is located adjacent to obstructions, the upper air discharging from the the cooling tower is mixed with ground air, thereby artificially raising the wet bulb temperature of the entering air. If a tower is to be located in a confined area, special precaution should be taken to make certain that vapors are carried away by the wind, or the general area will tend to saturate, and the ambient wet bulb temperature of air entering the tower will be increased. James G. DeFlon, The Fluor Corp., Ltd., Los Angeles.

What are the cooling jobs best suited to air-cooled exchangers in a natural gasoline plant?

It normally is impractical to attempt to approach the air temperature more closely than 20 to 30° F. A closer approach will result in a disproportionately large increase in heat transfer surface required and fan horsepower necessary. Therefore, assuming a maximum summer air temperature of 100° F, the air-cooled exchanger would be used for cooling jobs down to 120-130° F in natural gasoline plant or refinery. A cooling water temperature to within 10° of the air's wet-bulb temperature would be practical with a cooling tower.

Common applications in natural gasoline plants at present are the cooling of overhead vapors to 120° F from the various stills and fractionators, also the aftercooling of gases leaving compressors and engine jacket water.

It is necessary, however, in deciding whether or not air-cooling is economically feasible in a specific application, to consider cost of doing the job with water. Ordinarily costs by both methods should be compared, making adequate allowance for water treating costs; cooling tower erection and maintenance expense must be considered. D. C. Corson, The Griscom-Russell Co., Tulsa.

Is there anything that can be done, besides flaring it, with the hydrogen sulfide removed from sour natural gas, where it would serve a useful purpose?

Usually the quantity of H_2S available is so small that it does not pay to attempt any other disposal means but flare it. Theoretically it could be burned under a boiler, but the corrosive nature of the combustion product would require special construction of the boiler setting, alloy tubes, special stack and the like.

Elemental sulfur may be recovered profitably providing the quantity of hydrogen sulfide amounts to at least an average of 20-30 tons daily—enough to justify a plant investment of $6000 per daily ton of H_2S—$120,000 to $180,000. It also may be converted to sulfuric acid by controlled oxidation with air, but again a sufficient quantity must be available to warrant an investment of approximately $15,000 per ton of H_2SO_4, and produce a product which will be competitive with either mined sulfur or acid from this relatively cheap raw material.

Pure sulfur is recovered by first burning the H_2S with air to sulfur dioxide and water. The resulting SO_2 gas is mixed with additional H_2S in a mol ratio of one to two and passed over an activated bauxite catalyst. Elemental sulfur and water are produced as a vapor, pass to a scrubber where the sulfur is condensed in a countercurrent stream of molten sulfur. Water, contaminated with sulfur vapor, SO_2, H_2S, and considerable nitrogen, is vented overhead.

Process steam is generated in a waste-heat boiler used to cool the SO_2 and water vapor mixture formed by combustion of H_2S with air. Additional heat must be removed from the process following the converter step. This usually is accomplished by cooling the molten sulfur by exchange (with water or air) before it enters the scrubber, to maintain an average scrubber temperature of approximately 300° F.

Plants may have one or two stages of conversion. A one-stage plant may be expected to recover from 80 to 85% of the H_2S as sulfur. The two-stage plant, which has a second converter and a second scrubber operating on uncondensables from the first stage, will recover a guaranteed minimum of 90% H_2S as sulfur. In practice actual yields of 95% and better are achieved. Ordinarily catalyst life is indefinite and regeneration unnecessary.

The presence of carbon dioxide in the feed gas, such as that coming from a purifier of the ethanolamine type, complicates the first step if in a mol ratio greater than unity. Natural gas then must be added to permit combustion of the sulfide. In general almost any mixture of H_2S and CO_2 may be processed in a plant of this type, although special techniques may be necessary in some cases.

The production of sulfuric acid from H_2S uses the identical first step. Thereafter the conventional "contact" procedure is followed without change.—R. M. Reed, The Girdler Corp., Gas Processes Division, Louisville.

How does natural gas affect lube oil systems, when in contact with the oil?

It largely depends on whether it is "dry" or "wet" gas. The wet gas condition naturally will break down the lubricating quality of the oil and cause considerable trouble unless the proper oil is used. In many instances, in extremely wet gas conditions we have gone to a steam cylinder stock for this purpose in lubrication. Due to the absorption of gas in the oil, which would be controlled by pressure, there also would be an increase in the flash temperature of the oil. I regard it as a bad practice to store lube oil in a tank in contact with gas. —J. B. Zachry, Worthington Pump & Machinery Co., Tulsa.

Which type of storage is most economical for propane: (a) high-pressure uninsulated tanks or (b) the low-pressure, refrigerated and insulated type?

The 30,000 gal. 200 psi. working pressure uninsulated tank is, as of now, more economical to build and operate than the low-pressure variety. However, there are some circumstances which favor refrigerated, insulated storage. Where large volumes of liquid are pumped in and out in a short period of time, such as in terminal and plant service, it will be found expensive to cool them down to the storage temperature, only to lose this work when they are withdrawn. Where the volumes are low, or transfers in and out infrequent, it may possibly be cheaper to use insulated and refrigerated storage.—G. L. Brennan, Warren Petroleum Corp.

Operating Results on Commercial Hypersorption And Fiber Glass Desalting Are Told to AIChE

A Staff Report by the Editors of PETROLEUM PROCESSING

DESCRIPTIONS of economically successful commercial installations of two recently developed processes of interest to the petroleum refining industry were among the 28 technical papers presented at the regional meeting of the American Institute of Chemical Engineers in Cleveland, May 9-12.

One is the first full-scale ethylene recovery unit at Dow Chemical Co.'s Midland, Mich., plant, built by Foster-Wheeler Corp., and using the new Hypersorption process developed by Union Oil Co. of California. The other is a commercial desalting unit employing glass fibers as a contacting agent, and installed at the Whiting refinery of Standard Oil Co. (Indiana). Both units have been in operation for about one year.

The Hypersorption unit at the Dow plant, with a throughput rate of about 75,000 SCFH of feed gas, has been yielding a product in which the ethylene content has been in the range of 91-92 vol.-%, from a charge stock in which the C_2 has averaged, for the most part, 4.5 to 6 vol.-%. It was described in a paper "Commercial Hypersorption Operation for Ethylene Recovery," by Howard Kehde, R. G. Fairfield, Joseph C. Frank, and L. W. Zahnstecher, Foster Wheeler Corp., and presented by Mr. Kehde.

The process itself, licensed by Union Oil and Foster Wheeler, has been described previously (PETROLEUM PROCESSING, April, 1947, pg. 300). It is essentially a fractionating technique employing a moving bed of activated carbon particles to adsorb selectively the desired hydrocarbons from lean gas streams.

Ethylene Loss Is Low

Figures disclosed by Mr. Kehde indicated relatively low operating losses. In addition to less than 0.1% ethylene passing out in the overhead discharge gas stream, about a 0.4% loss is incurred in the purge gas stream. Carbon loss, averaging about 90 lbs./day recently, has been considerably higher than that anticipated at first. However, with the return to availability of superior grade carbons this loss, due chiefly to attrition and dust carryover, is expected to be reduced, Mr. Kehde said.

After earlier operating difficulties were overcome, the efficiency of the unit was gradually improved. During the last four months, onstream time has averaged about 95%, according to Mr. Kehde. Operation is almost completely automatic. The unit requires about one-half a man day. The Hypersorption unit operator at Midland divides his time between it and several other processes.

Utility requirements are relatively low considering the capacity of the unit. Cooling water averages 192 gpm., fuel gas of 600 Btu runs at about 2950 SCFH, and saturated 150 lb. steam is about 1360 lbs./hr. Almost 2/3 of the steam utilized is needed to operate the steam turbine-powered blower for circulating gas streams on the unit, Mr. Kehde said.

Special Control for Flow

Mechanical features of the Hypersorption unit were described at some length and include a special control device for regulating flow of the moving bed of carbon. This device consists of two trays each with a series of equal size vertical downcomers. The top tray is installed in a rigid position in the tower. A second tray is mounted just below the first so that it can be moved back and forth in a horizontal plane, thus effecting varying sizes of openings because of the changes in position of the downcomer tubes. In addition to flow control, the device prevents unwanted channeling.

In answer to questions raised during the discussion period, Mr. Kehde said the process will work economically on feed gases with C_2 content as high as 50%. Anhydrous columns can be designed also, for HCl adsorption for example. Applications are now being studied for the use of the process in recovering valuable materials from the huge quantities of coke-oven gas produced daily by the steel industry.

The use of glass fibers in a full-scale crude oil desalting unit was described in a paper entitled "A Commercial Desalting Unit Employing Fiberglas as a Contacting Agent," by J. G. Hayes, Owens-Corning Fiberglas Corp., and L. A. Hays and H. S. Wood, Standard Oil Co. (Indiana), and presented by Mr. Hayes.

Installed on a 10,000 b/d refinery unit, the glass-packed desalter has, with aid of a small percentage of chemical demulsifier, averaged about 87% salt removal since going on stream in January, 1947. Water and sediment carryover in the crude has run about 1.5%. Normal throughput of the unit is about 400 b/hr. It has been handling a West Texas crude containing 100 to 200 lbs. of salt per 1000 bbl. of oil.

No new vessels were built. A conventional excelsior-packed desalter was modified to handle the packing, which is a specially formulated acid-resistant glass in the form of fibers, 0.00028 in. in diameter. The fibers are laid down on a horizontal steel wire cloth grating, 8-mesh, in loosely-packed bats. Packing density is kept to about 2¾ lbs./cu. ft. The bats are placed in four criss-crossing layers.

The amount of demulsifying agent used has been low. It has averaged 0.32 gals per 1000 bbls. of oil processed, as compared with 65 gals./1000 bbls. needed for conventional excelsior type units, Mr. Hayes stated.

The results of some 25 engineering tests run on a catalytic polymerization unit at Sohio's Lima refinery were reported in a paper entitled "Correlation of Operating Variables in Catalytic Polymerization," by Jack H. Steffens, Marlin U. Zimmerman and M. John Laituri, Standard Oil Co. (Ohio), and presented by Mr. Zimmerman.

In summary, the authors showed that the conversion of olefins in the feed increases with (1) increase in catalyst activity, (2) increase in reactor temperature, (3) decrease in olefin space velocity, (4) decrease in total space velocity, and (5) decrease in olefin composition ratio (weight ratio of propylene plus normal butylenes to isobutylene).

No relationship could be found between the operating variables and the octane rating of the polymer produced, the authors stated. However, as reactor temperature is increased, an increase in the ASTM 50 and 90% distillation points of the polymer was observed.

Results Check Predictions

A chart was given for readily predicting the weight-percent conversion of the olefins in the total feed for a wide range of operating conditions. The actual deviation of the predicted conversions from the actual conversions obtained from the 25 tests used in developing the correlation is ± 2.5 wt.-%. Twelve other plant tests were used to check the correlation and were shown to have an average deviation of ± 2.9 wt.-%.

Diesel Fuel of 50-Cetane Value Produced In New Sulfur Dioxide Extraction Plant

By S. W. DICKEY, General Petroleum Corp., Los Angeles

Special feed drying facilities in a new Edeleanu treating plant insure that water entering the system and absorbed by the liquid SO_2 does not reach corrosive limits. Bubble tower drying of the SO_2 vapor stream, in place of use of concentrated sulfuric acid, has been found effective. Removal of SO_2 from product streams is by bubble towers in place of shell type evaporators. Switching of charge stocks is effected smoothly while the unit is running.

The plant was designed to produce 50-cetane diesel fuel oil at a charge rate of 5000 b/d with SO_2 contact of 6250 b/d; to process kerosine at 5000 b/d and naphtha at 4100 b/d. The plant was designed and constructed at Torrance, Calif., by E. B. Badger & Sons Co., Boston, in collaboration with General Petroleum Corp. engineers.

THE Edeleanu process is based on the selective solvent principle employing liquid sulfur dioxide as the extraction agent. Essential features include a treating tower for contact of oil and SO_2, evaporator systems for recovery of SO_2 from raffinate and extract streams, facilities for continuously drying the SO_2, and a filter and deaerator system for removing moisture and air from the charge oil. A refrigeration system must also be included to maintain a low treating temperature.

Liquid SO_2 has the property of extracting compounds of high carbon-to-hydrogen ratio, such as aromatics and olefins. Removal of these compounds is desirable since their presence causes a diesel oil to have a low cetane number and impairs the burning qualities of a kerosine. Also, compounds containing sulfur, nitrogen, and oxygen are removed, which further improves product qualities.

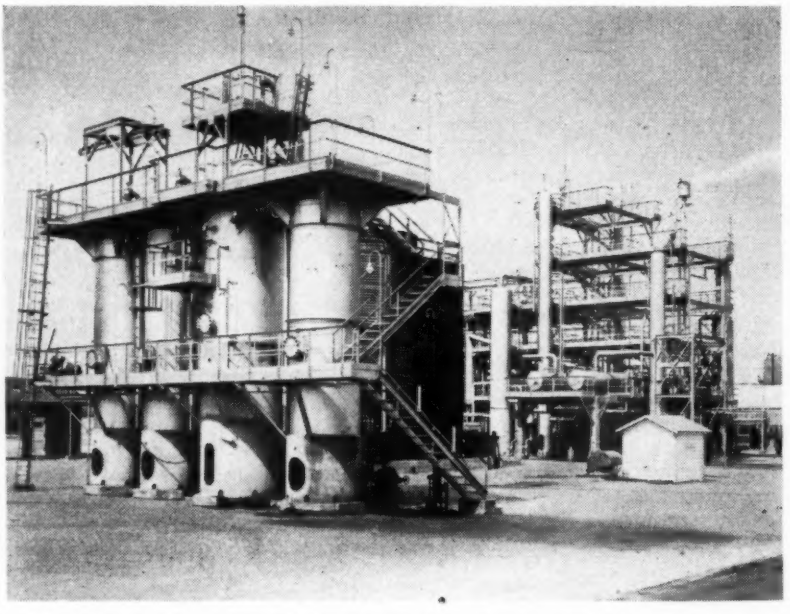
In the process, oil and SO_2 continuously enter the treating tower where they are intimately contacted. At the low temperature maintained, the SO_2 is not miscible with the paraffinic type of hydrocarbons and the SO_2-extract phase forms a bottom layer due to its greater density. The extract solution is then sent to a series of evaporators to recover SO_2; and the raffinate, containing a small amount of SO_2, is treated in a similar manner.

Degree of extraction is dependent upon the ratio of SO_2 to oil, temperature of treatment, and intimacy of contact. An increase in SO_2-to-oil ratio will result in a greater degree of extraction, which means a higher quality raffinate at a reduced percentage yield. In all cases care must be taken to avoid the formation of a single phase which would result from the treating temperature being too high or the SO_2 contact ratio being too low. Importance of treating at a low temperature is evident, but the level to which the temperature can be reduced is controlled by the pour point of the oil.

Fig. 1 is a flow diagram of the unit and shows conditions of temperature and pressure at control points in the system when producing 50-cetane automotive diesel fuel. Operating conditions for both 50-cetane diesel and kerosine production are shown in Table 1 and yields and properties of the two commodities are given in Table 2.

In charging stocks to the SO_2 plant extreme care must be taken to insure the charge stock being completely free of water. To this end diesel oil is given an air blowing treatment before pumping into the SO_2 plant charge tank. A perfectly clear stock is obtained in this manner. Kerosine is given a caustic treatment to extract naphthenic acid as it comes from the crude units and a short period of settling in the charge tanks is a satisfactory means of drying this stock. Naphthenic acid is not removed from the diesel oil ahead of the SO_2 treatment because of the difficulty of eliminating the resultant cloud. Therefore, the naphthenics are present during treatment and concentrate in the extract product, from

This Month's Cover Picture



General view of the new Edeleanu treating plant installed at the Torrance, Calif., refinery of General Petroleum Corp. Towers in foreground are, from right to left in direction of flow: sand filter, vacuum deaerator, and calcium chloride driers No. 1 and No. 2. At the right is the central structure of the unit, which is shown in more detail on page 542

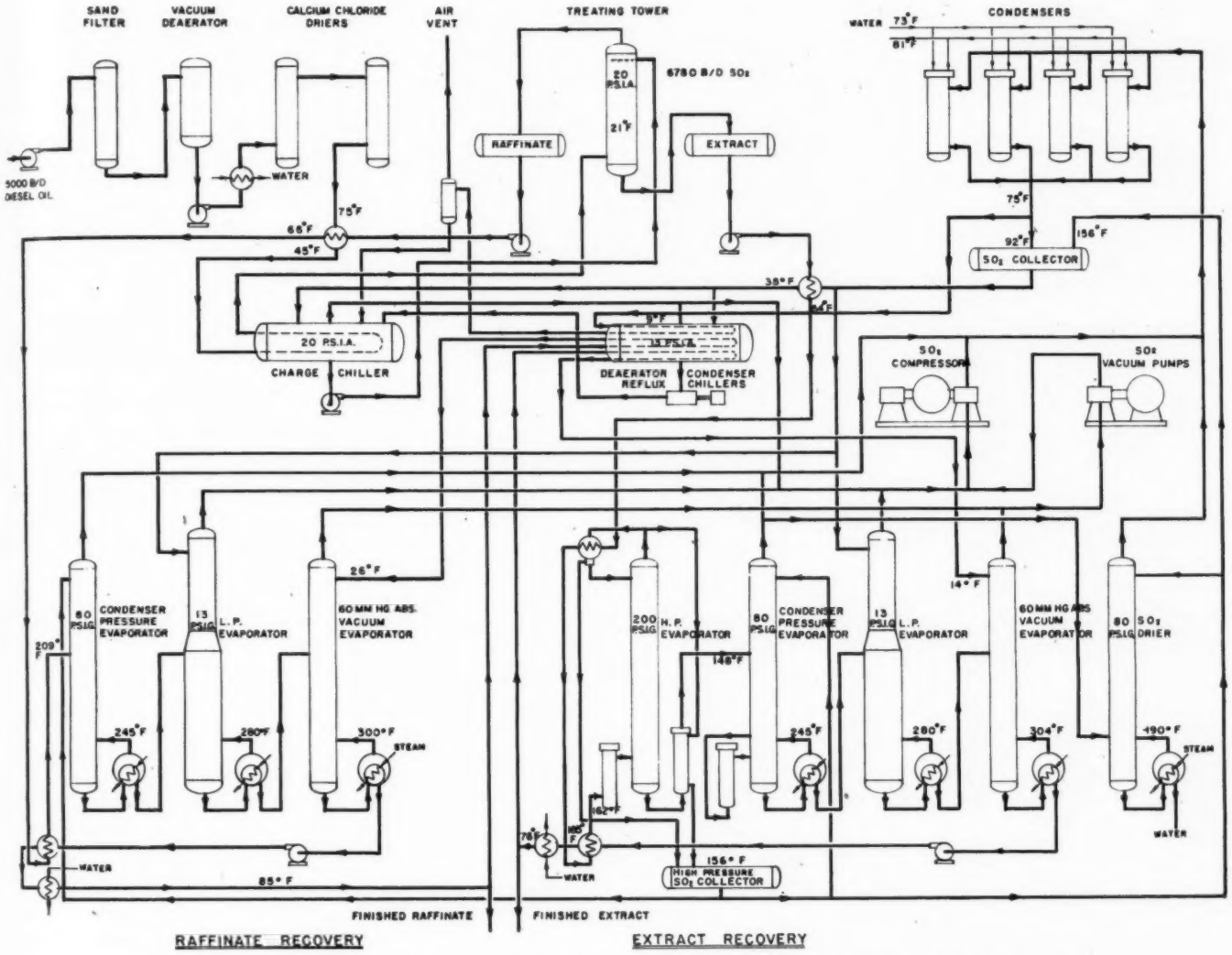


Fig. 1—Flow diagram of SO_2 extraction plant at Torrance, Calif., refinery of General Petroleum Corp.

which they are recovered by a caustic wash. The naphthenic acids are removed from these stocks for further refining and subsequent marketing.

Further feed drying facilities are located within the SO_2 plant. The feed passes first through a sand filter to remove any suspended droplets of water entering with the charge stock. Presence of such suspended moisture is rare, however, because of the elaborate precautions taken to dry the stock. An alarm in the bottom of this vessel sounds warning if a large amount of water should accumulate.

A vacuum deaerator is next in the order of flow, which removes dissolved air from the oil. High and low level alarms are part of the equipment, and the oil level is held constant automatically.

From this vessel, the oil is charged through a cooler to two calcium chloride driers in series and thence to the unit proper. A water alarm at the outlet of the cooler provides additional safety against water entry. The driers are to remove final traces of moisture from the feed and can be operated in series, parallel or singly, although the usual flow is in series. At present, for purposes of the test, the flow is up through the first drier and down through the second. It is believed that upflow prevents packing of the calcium chloride granules, but it is advantageous to operate the second drier downflow to prevent carry-over of the drying agent into the unit.

The filter and driers are frequently checked to remove water from the system and periodic inspections of the driers determines the rate of calcium chloride usage. After a period of four months, the first drier had shown a loss of ½ the original calcium chloride content which amounted to a usage of 12.5 lbs. per 1000 bbls.

From the drying system the charge passes through heat exchange with cold raffinate and thence through the tubes in the charge chiller to the bottom of the treating tower. The charge chiller shell contains liquid SO_2 cooled by autorefrigeration which is dependent upon vaporization to the SO_2 compressor suctions. Liquid SO_2 is fed to the charge chiller from the main collector, passing through heat exchange with cold extract solution enroute. SO_2 is then pumped from the charge chiller to the treating tower, entering at the top through a distributing ring and passing down through a section packed with 1¾ in. Raschig rings.

Contact is thus made as SO_2 flows downward through the oil, extract solution settling out at the bottom of the tower and raffinate solution passing over the top. Flow of extract solution from the tower is regulated by an interface level controller, which operates on the gravity differential between raffinate and extract solutions. When producing 50-cetane automotive diesel oil, the extract solution contains 84%-wt. SO_2 and the raffinate solution 15%-wt. SO_2.

Raffinate and extract solutions collect in their respective accumulators, from which they are sent to evaporators to recover SO_2. Three evaporators are used for processing raffinate solution, and four for extract. Both systems employ a condenser

TABLE 1—Operating Data on SO_2 Extraction Unit

	50-Cetane Diesel Oil	Kerosine
Charge Rate, b/d	5,000	4,550
SO_2 Rate, b/d	6,750	7,300
SO_2 Contact Ratio, %	135	160
Temperatures, °F		
Treating Tower	21	8
Charge Chiller (Shell)	27	14
Deaerator Condenser (Shell)	9	10
Main SO_2 Collector	92	95
High Pressure SO_2 Collector	156	156
Extract Evaporators		
Condenser Pressure Reboiler	245	234
Low Pressure Reboiler	280	280
Vacuum Reboiler	304	306
Raffinate Evaporators		
Condenser Pressure Reboiler	245	235
Low Pressure Reboiler	280	280
Vacuum Reboiler	300	304
Pressures		
Charge Chiller, psia	20	15
Deaerator Condenser, psia	13	13
Treating Tower Top, psia	20	15
Extract High Pressure Evaporator, psig	200	200
Condenser Pressure Line, psig	80	80
Low Pressure Line, psia	13	13
Vacuum Evaporator Line, MM Hg Abs.	60	190

pressure evaporator, low pressure evaporator, and vacuum evaporator, but the extract system also uses a high pressure evaporator. Reboilers incorporate temperature and level controllers and are operated on 175-lb. steam. Advantage is taken of the pressure differential between each tower to transfer liquid through the system instead of using pumps.

Extract is pumped from the accumulator at the treating tower through heat exchange with SO_2 feed followed by heat exchange with SO_2 vapor from the high pressure evaporator and next with hot extract from the vacuum evaporator. Final heat adjustment before entering the high pressure evaporator is made by a heater operating on 10-lb. exhaust steam. The heat applied at this point is controlled automatically to hold a 200-psig pressure in the vapor of the high pressure tower. Vapor from the high pressure tower is condensed by heat exchange with incoming extract solution and with bottoms from this tower which have cooled by flash to the 80 psi. pressure of the condenser pressure tower.

A portion of the SO_2 liquid formed by the vapor heat exchange with incoming extract solution is used for reflux to the high pressure tower. Excess liquid from this source plus that from the condenser pressure feed exchanger is accumulated in the high pressure SO_2 collector and used for reflux to the two condenser pressure evaporators and the SO_2 drier. Excess SO_2 in the high pressure collector is transferred to the main collector by a level controller.

Extract next flows on level control to the condenser pressure evaporator, which operates at sufficient pressure to condense the overhead SO_2 vapors, joined by vapors from the raffinate condenser pressure tower, at the cooling water temperature. A portion of the vapor is diverted by means of a remotely controlled butterfly valve to furnish feed vapor for the SO_2 drier.

The extract low pressure evaporator takes its feed from the condenser pressure reboiler and operates at compressor suction pressure which is on automatic control. Vapors from the raffinate low pressure evaporators are furnished reflux from the main SO_2 collector. Extract next flows to the vacuum evaporator where final traces of SO_2 are removed. Vapor from this tower is joined by vapor from the raffinate vacuum evaporator enroute to suction of the vacuum pumps. These pumps discharge into the suction of the SO_2 compressors along with vapors from the deaerator condenser, charge chiller, and low pressure evaporators. Discharge from the SO_2 compressors enters the condenser pressure vapor line which conducts vapors into the condensers.

Liquid SO_2 from the condensers is then returned to the main collector to be used again for circulation in the process. The vacuum evaporators are furnished reflux from finished raffinate and extract streams respectively which have been chilled by passing through tube bundles in the deaerator condenser. Finally, extract is pumped from the vacuum reboiler through heat exchange with incoming extract solution, followed by a cooler, and then passed through a caustic treating shell and into storage.

Raffinate solution is pumped from its accumulator through heat exchange with incoming oil charge, then through heat exchange with hot oil from the raffinate vacuum evaporator. It next enters the raffinate condenser pressure evaporator and passes through the series of evaporators in the manner described for the extract system. Oil from the raffinate vacuum reboiler exchanges heat with incoming raffinate solution, is further cooled by a water cooler, and pumped to storage.

Extract and raffinate vacuum evaporators are operated in a manner to yield products completely free of SO_2. It is necessary to operate the vacuum reboilers at temperatures sufficient to boil the light front ends of the oil as an aid in stripping out SO_2. The temperature is fairly criti-

TABLE 2—Yields and Properties

50-Cetane Diesel Oil	Charge	Extract	Raffinate
Volume % Based on Charge	100.0	25.0	75.0
Cetane No.	40.0	.....	50.0
Color—Union	3	6	1—
Flash Point, °F	180	180	180
Viscosity—SU/100	35	35	35
Water and Sediment	0.0	.....	0.0
Pour, °F	—30	.....	—15
Sulfur, %	0.34	1.25	0.09
Conradson Carbon in 10% Bottoms	0.04	0.22	0.02
Aromatics and Unsaturates	24	78	3
Aniline Point, °F	139.6	13.9 (Calculated)	169.5
Gravity, API	32.8	20.7	38.2
Distillation, °F			
Initial	390	396	394
5%	434	434	436
10%	446	444	446
20%	458	457	458
30%	467	467	469
40%	477	478	480
50%	489	491	493
60%	503	504	507
70%	519	519	523
80%	539	538	542
90%	566	564	567
End Point	616	628	614
Recovery	99	99	99

Kerosine	Charge	Extract	Raffinate	Acid Treated Raffinate
Volume % Based on Charge	100.0	23.5	76.5	.....
Color, Saybolt	14	.....	30+	30+
Color Stability, Saybolt	.....	.....	30+	30+
Color, Union	.....	1½	.....	.....
Flash Point, °F	140	144	134	.....
Thermal Viscosity	355	335	385	385
Sulfur	0.19	1.02	0.05	0.03
Conradson Carbon in 10% Bottoms	0.02	0.05	0.006	0.001
Aromatics & Unsaturates, %	18	75.0	2.0	1.0
Aniline Point, °F	128.8	16.9 (Calculated)	156.0	156.4
Smoke Point	18	.....	27	27
72-hour Burning Test	.....	.....	Failed	Good
Gravity, A.P.I.	38.4	26.8	42.5	42.4
Distillation, °F				
Initial	347	345	340	340
5%	370	367	365	366
10%	376	376	376	377
20%	389	391	390	391
30%	401	403	400	403
40%	412	414	411	413
50%	422	425	422	423
60%	432	435	431	432
70%	441	445	441	441
80%	454	458	453	453
90%	467	473	468	468
End Point	500	509	499	500
Recovery	99	99	99	99

cal, since too high a temperature will drive oil into the vacuum vapor trap and too low a temperature will permit the presence of SO_2 in the product.

A 3 ft.-6 in. x 28 ft. steel tower is used for air blowing the raffinate to remove the SO_2 when it appears in the stock during periods of upset. This tower has been fitted with 5 bubble trays and is connected to permit oil to flow down from the top against a stream of air rising from an inlet at the bottom. An air rate of 25 mcf per hour will remove the SO_2 from a diesel raffinate containing up to 50 ppm. If the SO_2 content of the raffinate should exceed the capacity of the air blowing tower, the stream can be treated in a horizontal shell containing an ammonia solution. This treatment yields a cloudy product which requires prolonged settling to clarify and, consequently, is used only during emergencies.

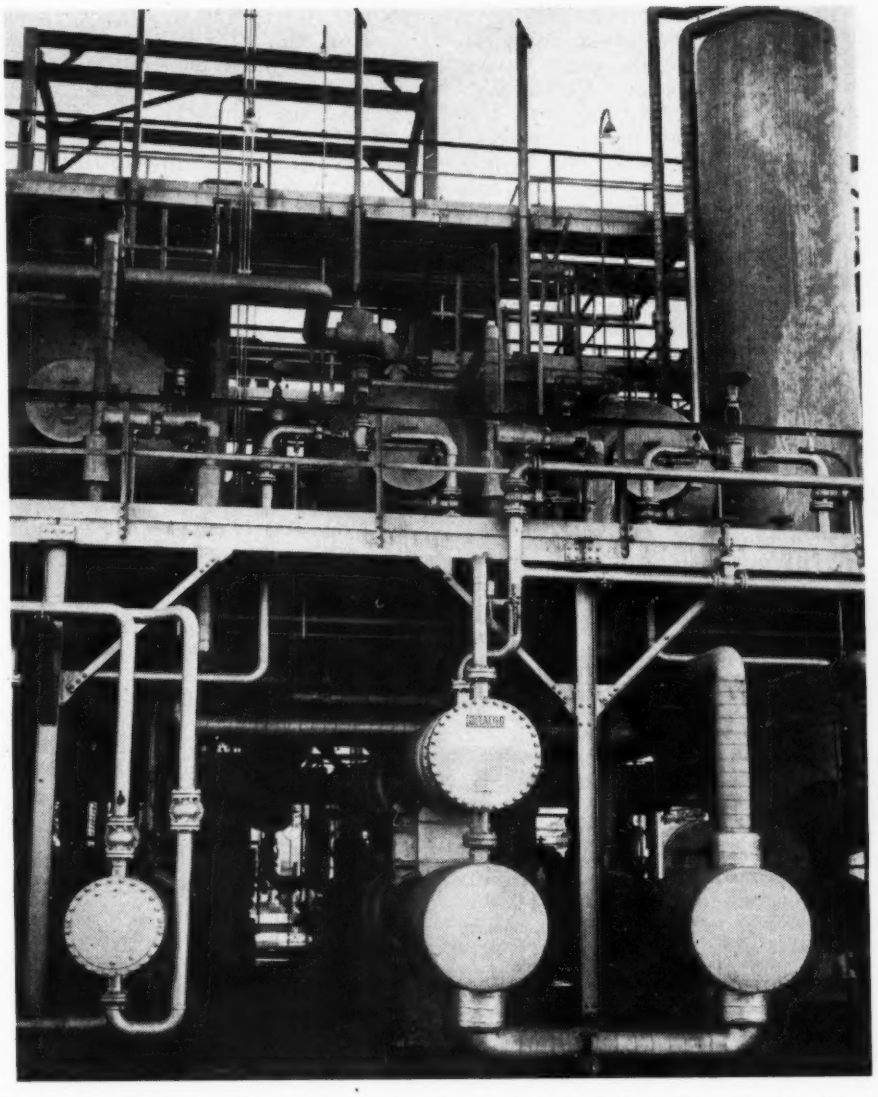
Deaeration

A small amount of air enters the system occasionally and accumulates in the SO_2 vapor sections operating at condenser pressure. This air must be held at a low quantity to maintain condenser pressures within practical limits. Removal is effected by means of a line connected to the condenser outlet. This vent gas passes through the deaerator condenser and enters a small pot to permit liquid SO_2 to drop out and be sent to the charge chiller by a level controller. Air is released from this pot by a motor valve operated remotely from the control house.

The deaerator condenser shell receives liquid SO_2 from a branch in the line feeding the charge chiller. A layer of SO_2 is held by level control in this vessel and is maintained at a low temperature by being in equilibrium with vapor at reduced pressure connected directly to compressor suction. This temperature, usually about 10° F, is normally lower than that of the charge chiller because vapors from the latter vessel pass through a motor valve before entering compressor suction and are held at a higher absolute pressure.

Liquid levels in the charge chiller, deaerator condenser, and extract solution accumulator are indicated by the use of an insulated vertical column with horizontal plugs protruding through the insulation at uniform intervals. This column is attached to the vessel at top and bottom in the manner of a gauge glass, and liquid SO_2 seeking its level in the column will chill the plugs causing them to frost and exhibit a visual indication of the liquid level within the shell.

Liquid SO_2 is continually pumped from the deaerator condenser shell into the charge chiller to prevent any increase in the concentration of water due to vaporization of SO_2. Air content of the vapor above the liquid in the main SO_2 collector is continuously recorded in the control house. This device operates from an instrument which transmits the differential pressure between the vapor pressure of pure SO_2 at the temperature of the main collector and the actual pressure in the main collector. This differential represents the air content of the system and is recorded in pounds.



Closeup of cooling and treating section. On upper deck, left to right, are the charge chiller (a refrigeration vessel), the deaerator condenser (another refrigeration vessel), raffinate solution accumulator, and the treating tower

SO_2 Drying

Despite precautions taken to dry the charge oil stream a small amount of water enters from this source, usually at a concentration of about 100 ppm. Moisture also enters the system with the air which leaks in. This water is absorbed by the liquid SO_2 and would soon reach corrosive limits if it were not continuously removed. Drying is effected by use of a 26 ft. fractionating tower. As mentioned earlier, the drier is fed by diverting the SO_2 vapor stream from the condenser pressure line. SO_2 vapor enters the drier near the bottom above a short section packed with 1 in. Raschig rings. A comparatively high reflux rate is used, and the SO_2 vapor is fractionated out of the water and passes from the top of the drier into the condenser pressure vapor line. A level of water collects in the reboiler which is held at a temperature sufficiently low to minimize vaporization of water. Water is drained to the sewer from the reboiler to hold the level within designated limits. Some SO_2 remains dissolved in the water, but the loss from this source is small.

This method of drying is very effective, resulting in a usual content of .03%-wt. in the liquid SO_2 feed to the system. This is quite low in view of the fact that the safe upper limit is considered to be 0.1%-wt.

A simple method of test, similar to that used by other west coast refineries, is used in the plant by our operators to determine the water content of the SO_2. In conducting this test 500 cc. of liquid SO_2 is measured into a liter flask fitted with a calibrated tip at the bottom. The SO_2 is permitted to evaporate, leaving the water behind in the tip where its volume can easily be measured and converted to per cent. The Karl Fischer method has been used by the laboratory to check the plant test, and conclusions drawn from these comparisons are that the plant test is sufficiently reliable for control.

Switching Stocks

Both diesel oil and kerosine stocks have been run in the unit to date, the switching from one stock to the other having been effected smoothly. The chief operational changes to be made during such a switch are treating temperature, ratio of SO_2 contact, reboiler temperatures, and evaporator pressures. During these periods the unit is kept running at a uniform charge rate, and oil levels in the sand filter and vacuum deaerator are lowered. The new stock is then cut in and allowed to flow through the unit displacing the previous stock. A time schedule is employed to make control changes at various points in the system at the approximate moment the new stock appears.

For example, in switching from diesel oil to kerosine the treating temperature should be reduced only after the diesel oil has been displaced to avoid getting close to the pour point of the diesel. At the time the kerosine reaches the vacuum reboilers the absolute pressure on this equipment must be increased from 60 mm.Hg. to 190 mm.Hg. to avoid flooding the towers. Similar considerations must be employed when going from kerosine to diesel stock.

Diesel oil from the SO_2 plant is sent directly to storage ready for marketing, but kerosine raffinate requires further treatment. This product meets all specifications except the lamp test and is sent to the acid treating section of the refinery, where it is treated with 98% sulfuric acid. The lamp test is thus improved, and the finished product meets superior grade kerosine specifications.

The unit embodies latest features in SO_2 extraction plant design. In contrast to early plants using shell type evaporators, the General Petroleum unit uses fractionation towers equipped with bubble trays for recovering SO_2 from product streams. SO_2 drying by use of concentrated sulfuric acid has been used by many plants since the inception of the process, but the more modern method of bubble tower drying is used in this plant because of its simplicity and trouble-free operation. Lines, shells, and towers in the plant are of carbon steel with the exception of the drier, lead lined upper section of the extract low pressure evaporator, and lead lined sump tank. All valves in service where SO_2 may be present are trimmed with stainless steel.

Evacuation lines are connected to vessels and lines in SO_2 service and lead to a manifold which permits suction through SO_2 compressors and vacuum pumps or entry into a sump tank which can be evacuated by means of an electric pump. Drain lines from vessels and lines are also connected to the sump tank which can be drained to the sewer, or the contents can be transferred by pressure into the extract low pressure evaporator if dry oil or SO_2 is present. Flushing oil is used on glands of liquid SO_2 pumps, extract solution pumps, and raffinate solution pumps. Purge oil is applied to the SO_2 flow controller, treating tower interface level recorder, and drier feed rate recorder.

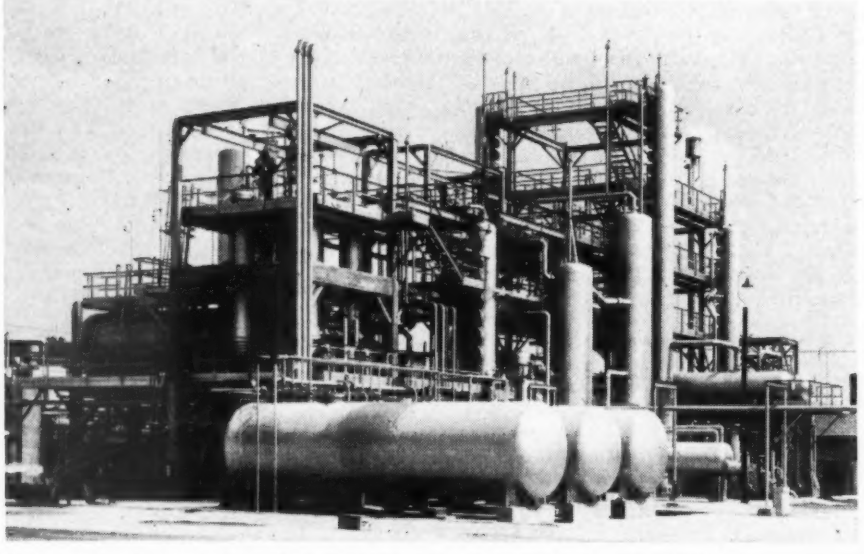
Fischer & Porter rotameters coupled with indicating transmitters and receiver recorders are used for controlling reflux streams. This system has proven very satisfactory for handling small streams which are likely to cover a wide range of rate due to changes in operating conditions. An emergency shutdown valve is operated from the control house and performs the function of shutting off the high pressure steam to all reboilers, closes off the make-up steam control to the exhaust steam line, opens the exhaust steam line to the atmosphere, and closes motor valves controlling oil and SO_2 charge rates. In the event of a sudden necessity for shutting the unit down this provides a convenient means of control. It is also useful for planned shutdowns under some conditions.

A cement pad has been placed around the entire base of the main structure for convenience of operation, maintenance work, and general cleanliness. All exchangers are positioned to permit the tube bundle to be removed onto a solid open area. Chain hoists are located at strategic points to facilitate removal of tube bundles or other equipment.

Cooling water is furnished from an induced draft tower equipped with a temperature regulator operating a by-pass on the return stream. Normally an electric driven pump is used for circulation of cooling water. A steam turbine driven pump is always ready as a spare and will start automatically, simultaneously sounding an alarm, in the event of failure of the main pump.

Lines, vessels, and exchangers handling cold oil or SO_2 are insulated with from 2 in. to 4 in. of vegetable cork. Pumps in this service are insulated with a cork box filled with granulated cork and wax. Equipment in hot service is insulated with an 85% magnesia coating. Towers, lines, and tanks are painted with aluminum.

Initial start-up of the unit was in September, 1947. Equipment was first pressure tested with oil and then subjected to drying procedures. Drying of all vessels and lines was effected by circulation with hot oil followed by operation of the unit using isobutane in place of SO_2. The isobutane and oil were then removed, the entire unit evacuated, and sufficient SO_2 was delivered, followed by the start of actual treating operations. Diesel oil was used as charge stock during these initial operations, and a product meeting all specifications was produced from the outset.



Central structure of the sulfur dioxide extraction unit, showing SO_2 storage tanks, one of the condensers, the drying tower, and the extract evaporators

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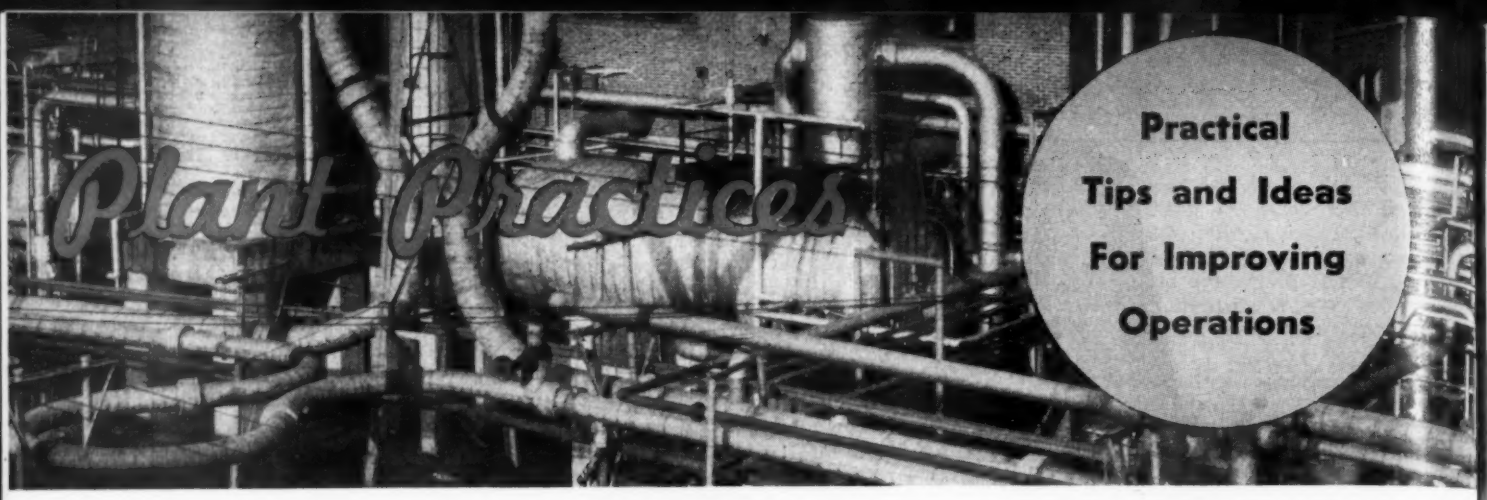


Improved Housekeeping Is Simple Task With Shop-built Waste Chute on TCC Unit

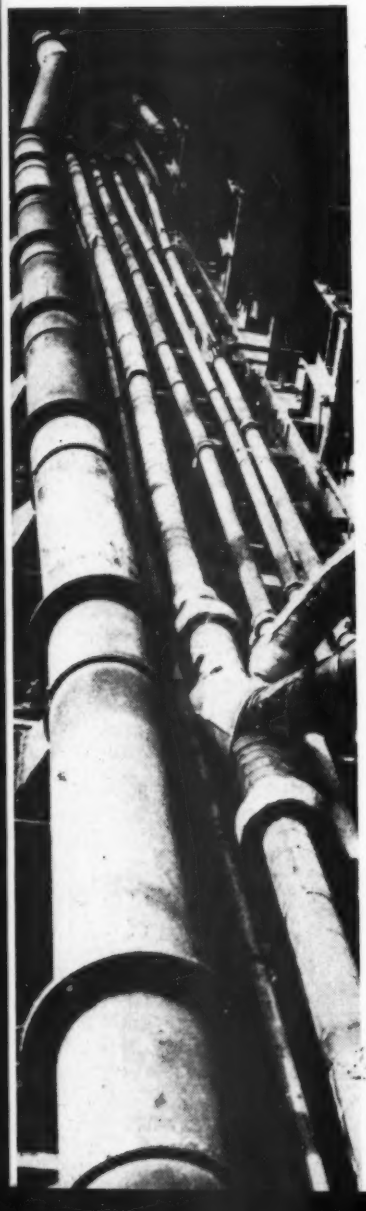
By BERNARD I. BELL, Technical Field Foreman
Sinclair Refining Co., Houston, Texas

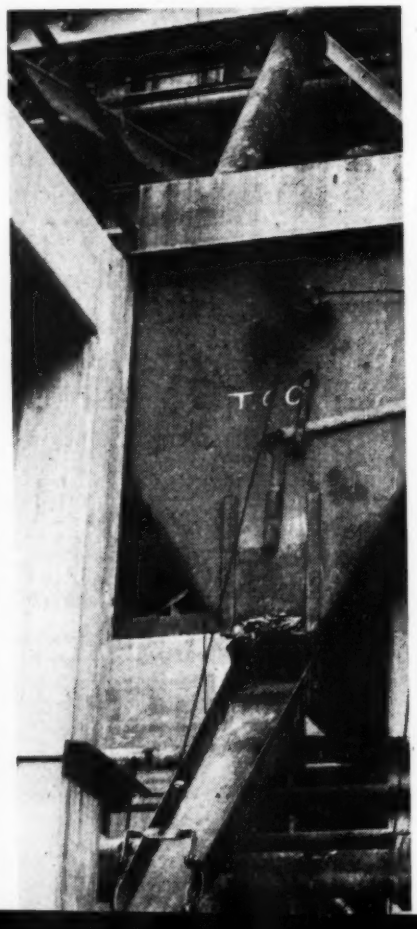
THE waste disposal chute described here was the outgrowth of a problem which involved cleaning waste catalyst and other debris from the platforms of a Thermofor catalytic cracking unit kiln structure. Prior to this installation, all waste was swept and shoveled into sacks, which were then lowered by a winch, or carried to the freight elevator and taken to the ground.

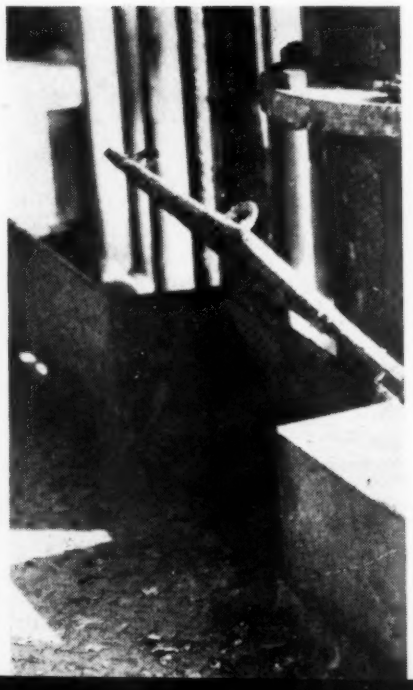
Now that waste is swept into the openings provided at each platform, whence it falls down the chute into a bin. From the bin, it is dumped into trucks to be hauled away.

The chute itself is constructed of scrap pipe, about 12-in. diameter. It is installed along one side of the kiln structure from the topmost platform to the bottom of the bin. At each platform, entries to the chute are set flush with the floor and are provided with hinged lids.

The bin has an opening at the bottom of one side, toward which the bottom of the bin slopes. This opening is fitted with a sliding panel which can be raised or lowered from the ground by means of a lever and cable arrangement. A trough is hinged to the bin below the opening, and can be raised or lowered to guide the waste into trucks.







Far left: pipe chute is held by brackets welded to TCC unit framework. Center: all waste drops into this bin and is dumped through the opening covered by sliding panel. Left: hinged openings are provided at each platform through which waste can be swept into the vertical chute

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Portable Mules Cut Labor Cost And Downtime on Overhead Job

WHEN TUBE bundles are to be removed from some of the upper platforms of the Houdry or the polyforming units in Socony-Vacuum Oil Co.'s East Chicago refinery, they must be lowered from an elevation 50 to 60 ft. above grade.

Use of a conventional, hand-operated chainfall required a crew of up to 5 men working a full shift of 8 hours to handle some of the larger and heavier bundles. Socony's maintenance engineers designed and built a portable, air motor driven unit that can be moved around the plant from job to job.

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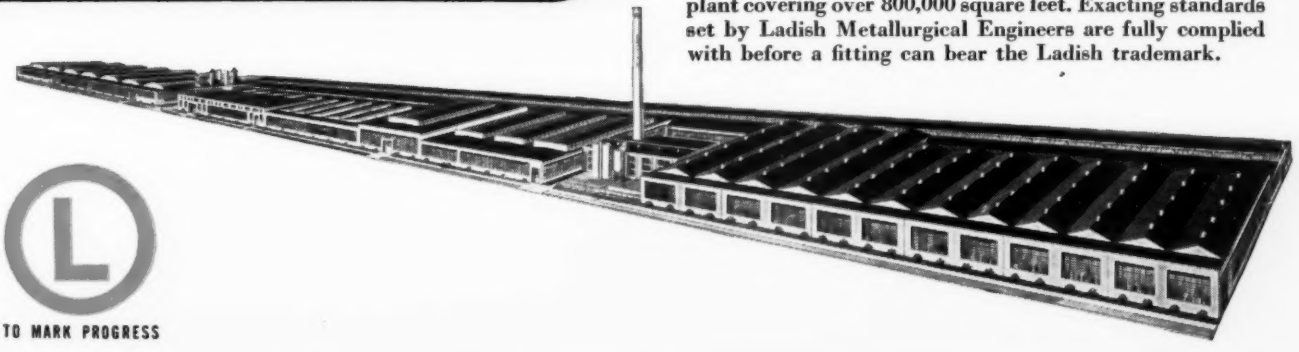

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This partial list of Du Pont fuel and lube oil additives is indicative of the results of a continuing program to produce new and better additives. Each has been produced to meet a specific need . . . to add to or enhance the desirable properties of petroleum derivatives, or to arrest or inhibit deterioration caused by oxidation, polymerization, or metal entrainment. Write for complete information. *E. I. du Pont de Nemours & Company, (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.*

NAME	DESCRIPTION	USE
Du Pont Gasoline Antioxidant No. 5	A solution of normal butyl-para-aminophenol in alcohols.	For reducing the formation of gum and improving the stability of leaded gasolines.
Du Pont Gasoline Antioxidant No. 6	A solution of isobutyl-para-aminophenol in alcohols.	For reducing the formation of gum and improving the stability of leaded gasolines.
Du Pont Gasoline Antioxidant No. 22	A commercial grade of N:N'-disecondary-butyl-para-phenylenediamine.	For reducing the formation of gum and improving the stability of leaded gasolines.
Du Pont Gasoline Colors	Du Pont Oil Orange Du Pont Oil Red Du Pont Oil Yellow N Du Pont Oil Blue	For color identification of gasolines.
Du Pont Metal Deactivator	An 80% solution of N:N'-disalicylidene-1:2 diamino-propane in xylene.	For improving the storage stability of petroleum distillates containing dissolved copper.
Du Pont Rust Preventive No. 1	A viscous, reddish-brown clear liquid, readily soluble in mineral oil at room temperatures.	At concentrations of 2-5% by volume in petroleum bases for imparting non-staining rust preventing properties.
"Ortholeum" 153	Fluorescent green liquid.	At concentrations up to 1% in motor oils and other lubricants to improve wear characteristics under conditions of boundary lubrication.
"Ortholeum" 202	A sulfurized terpene containing approximately 34% sulfur of controlled activity.	As a sulfur carrier where moderate sulfur activity is desired.
Du Pont Phenyl-alpha-naphthylamine	Crystalline solid.	Oxidation inhibitor for various products.
Du Pont Phenyl-beta-naphthylamine	Powder.	Oxidation inhibitor for various products.
Du Pont Tributyl Phosphite	Water-white liquid.	At a concentration of about 0.5% in oils as a mild antioxidant and as a wear reducing agent.
Du Pont Tetraethyl Lead Compound—Motor Mix	Yellow liquid antiknock compound the principal component of which is tetraethyl lead.	In concentrations up to 3.0 cc./gallon as an antiknock agent for motor gasolines.
Du Pont Tetraethyl Lead Compound—Aviation Mix	A blue liquid antiknock compound the principal component of which is tetraethyl lead.	In concentrations up to 4.5 cc./gallon as an antiknock agent for aviation gasolines.
Du Pont Fuel Oil Stabilizer No. 1	A blend comprising an antioxidant and metal deactivators in isopropanol.	Added to cracked furnace and diesel oils in concentrations of 0.001 to 0.01% by weight to improve storage stability.

Gasoline Oxidation Inhibitors
Oil Soluble Colors
Lubricating Oil Additives
Fuel Oil Additives
Metal-Working Lubricants
Corrosion Inhibitors

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one man to do the same operation in about three hours. This represents an approximate saving in labor cost of 40 minus 3, or 37 man-hours. In addition, downtime is reduced by 5 hours.

The portable "mule" is shown in a simplified end view in Fig. 1. A stout, steel skid serves as the base for an air motor of suitable power. Mounted on the drive shaft of the motor is a conventional chain hoist sprocket around which the operating chain is wrapped. In addition, a conventional drum is mounted on the shaft for the many horizontal "mule" jobs around the plant.

A hand-type adaptation of the same idea has been built also and is shown in Fig. 2. The operator holds the one end of the shaft by the handle; the other is connected to an air motor by the shank.

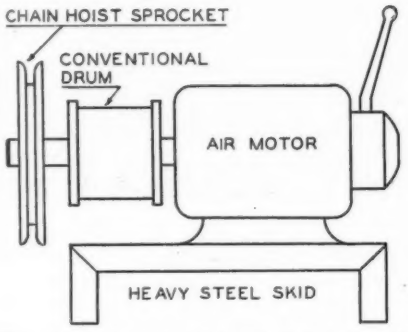

Fig. 1—End view of "mule" fitted with chain-hoist sprocket for use as drive means for chainfalls

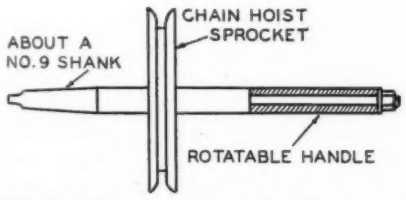

Fig. 2—Same idea as adapted for use as portable hand-tool

Need for Elaborate Scaffolding Eliminated By Using "Inverted Umbrella" Platforms

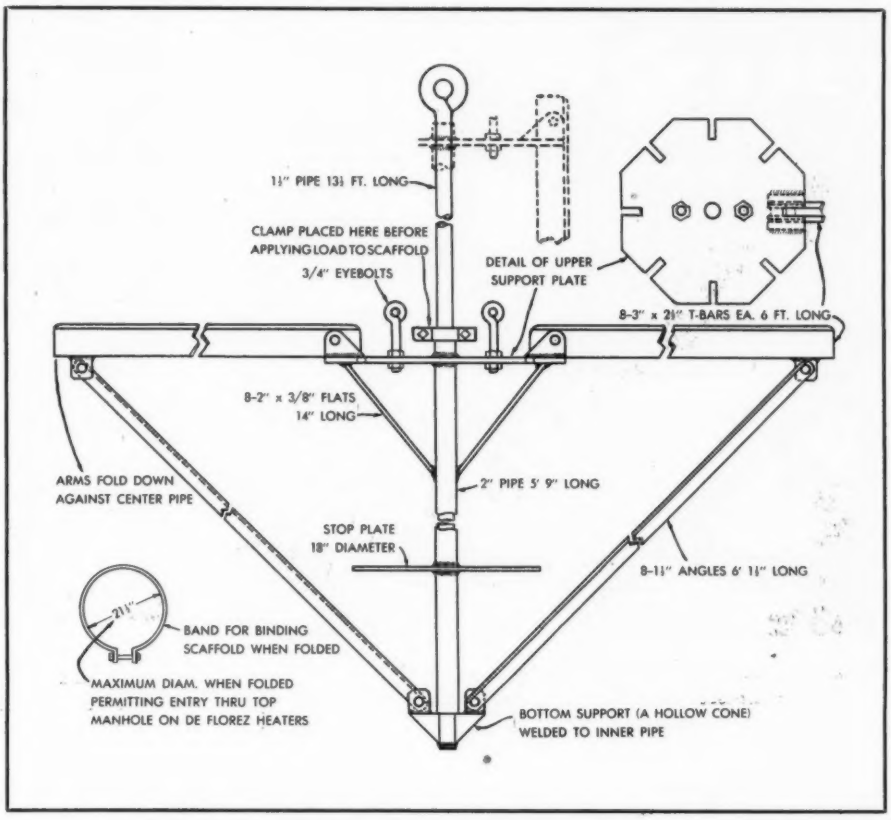
1½" PIPE 13½ FT. LONG
CLAMP PLACED HERE BEFORE APPLYING LOAD TO SCAFFOLD
3/4" EYEBOLTS
DETAIL OF UPPER SUPPORT PLATE
8-3" x 2½" T-BARS EA. 6 FT. LONG
8-2" x 3/8" FLATS 14" LONG
ARMS FOLD DOWN AGAINST CENTER PIPE
2" PIPE 5' 9" LONG
STOP PLATE 18" DIAMETER
8-1½" ANGLES 6' 1½" LONG
21½"
BAND FOR BINDING SCAFFOLD WHEN FOLDED
MAXIMUM DIAM. WHEN FOLDED PERMITTING ENTRY THRU TOP MANHOLE ON DE FLOREZ HEATERS
BOTTOM SUPPORT (A HOLLOW CONE) WELDED TO INNER PIPE

Fig. 3—Schematic drawing of Sinclair's "umbrella" scaffold

"UMBRELLA" scaffolds are used to simplify maintenance and inspection on downshot-type, de Florez furnaces at Sinclair Refining Co.'s East Chicago plant. They make it possible for workmen to reach the upper sections of the furnace interior to inspect or repair insulation without first erecting elaborate scaffolding from the bottom floor of the furnace.

The devices work much like a suspended umbrella, as is illustrated in Fig. 1. In use, it is first folded into a bundle with the 8 side-arms parallel to the center pipe and secured in place by the metal band shown. Thus, it forms a bundle only about 22 in. in diameter, small enough to enter the top, central manhole in the furnace.

The bundle is then suspended vertically from wire rope or chain of proper strength strung from a hoist on one of the overhead trolley beams on the furnace's superstructure. It is lowered inside the furnace, opened up, and clamped. Additional support cables are secured in position, and then scaffold planks are laid on top the 8 side-arms in a hexagonal arrangement.

The scaffold thus formed is about 13 ft. in diameter, while the furnace interior is about 30 ft. in diameter. When it is desired to reach out closer to the sidewalls, wooden extensions can be lashed to the side-arms of the umbrella and provided with additional support by metal rods suspended through each of the four top peepholes in the furnace.

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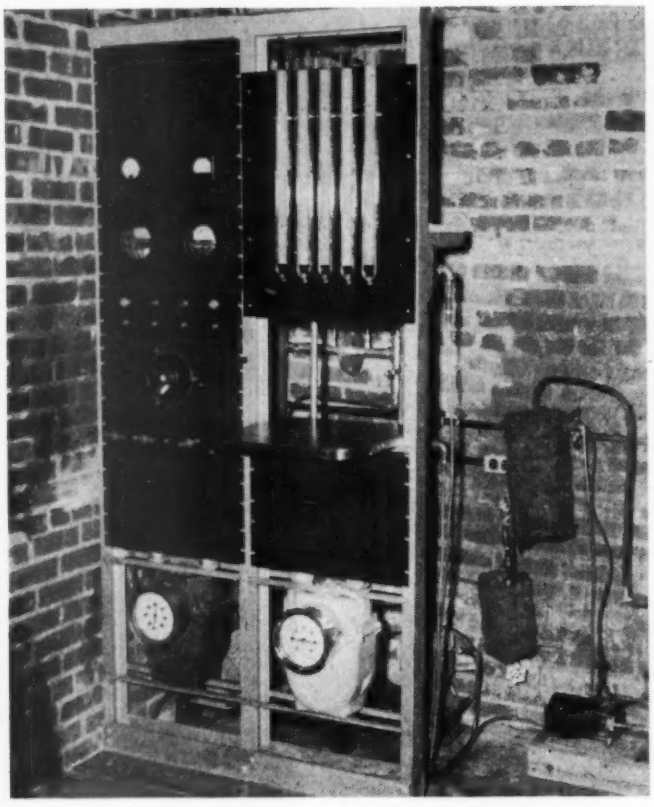
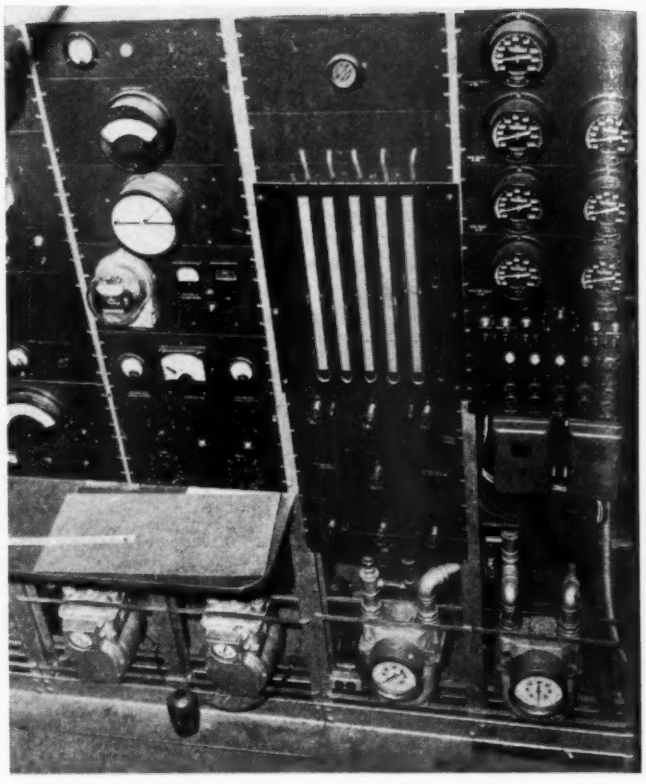


Here, a double-type rack mounts five manometers, two watt-hour meters, controls, transformer, two gas meters



A pilot plant control panel group of instruments mounted on a set of standard relay racks to form a multiple unit

Relay Racks Make Rigid, Compact Stands For Laboratory and Pilot Plant Apparatus

ONE OF the most commonly encountered problems around laboratory and pilot plant is that of mounting equipment rigidly, safely and compactly. "Unitized" mountings often are desirable also, particularly when the set-up is intended to be moved to various points of use or stored as a unit.

Extensive use of so-called "relay racks" and standard panels is made in Skelly Oil Co.'s research laboratories for various purposes. The racks are made from channel iron or I-beams, although a less sturdy type may be purchased from most radio and electrical supply houses. Figs. 1 and 2 are two common types, and the photographs illustrate typical uses. No patent infringement is involved in their construction or use, the company has advised.

It will be noted in Figs. 1 and 2 that the standard clearance between any pair of uprights always is maintained at 17-1/2 in. Screw-hole spacing shown in Fig. 1 likewise is standardized. This is important for, by maintaining these dimensions, the racks will accommodate any commercial panel having so-called "Western Electric notching". All panels of this type are 19 in. long and available in 12 widths, ranging from 1-3/4-in. to 21-in.

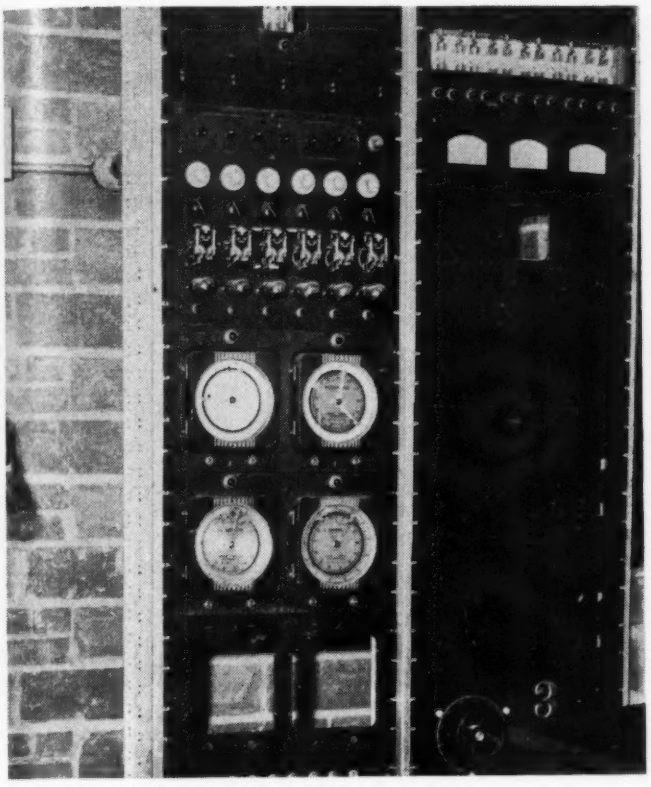
Panel materials commercially available include aluminum, steel and masonite. They also are available ready to use for meter mounts, or having metal and ventilated doors and enclosed boxes as well as shelves (which serve as desks at control panels).

High precision distillation columns are mounted on relay racks, with some specially modified to take the columns. All controls, including variable voltage transformers, "Flexo-Pulse" instruments, transformers, connection plugs for thermocouples, control instruments and so on are similarly, but separately, mounted.

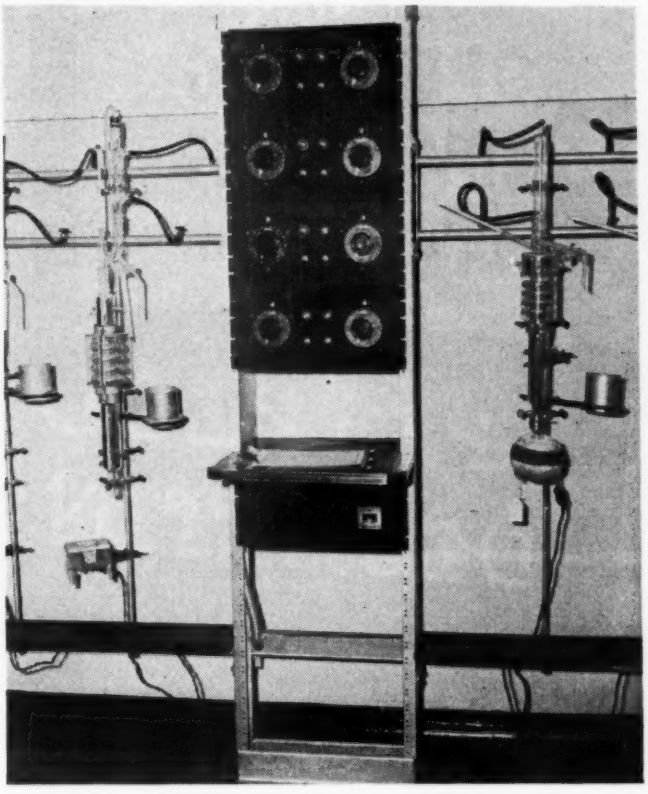
Other common equipment handled in this way includes electrical and mechanical meters and gauges of all kinds, manometers, Orsat analyzers,, low temperature fractionating equipment, all types of electronic equipment and temperature and pressure recorders and controllers. The latter are easily installed by use of adapter strips attached on each side with the customary instrument mounting bolts.

All control equipment for pilot units is mounted on single or multiple type relay racks, some of which have been modified for special purposes. In addition, short distillation columns and pots are mounted in this manner, many times complete with receivers and condensers or allied equipment. Similarly, heat exchangers and small furnaces can be incorporated where needed.

The advantages of this system are in the neat, compact appearance, space-saving construction and ready interchangeability of one panel from any rack in the laboratory to any other rack elsewhere. This is of particular advantage, since equipment is continuously being disassembled or constructed as problems change. Often whole portions of controls can be re-used.



Portion of a control panel for high precision distillation control instruments



A single-type panel and operator's desk for a four-column distillation unit

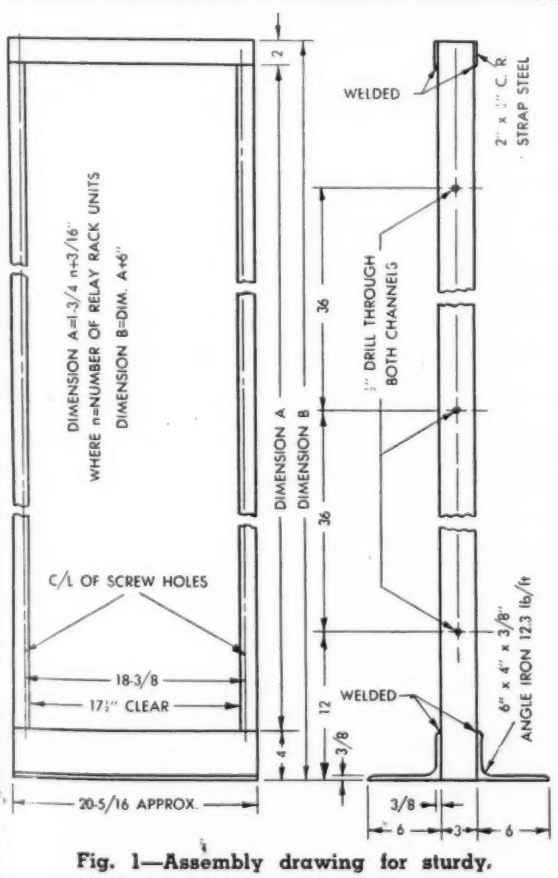


Fig. 1—Assembly drawing for sturdy, single-type relay rack taking commercial panels with "Western Electric notching"

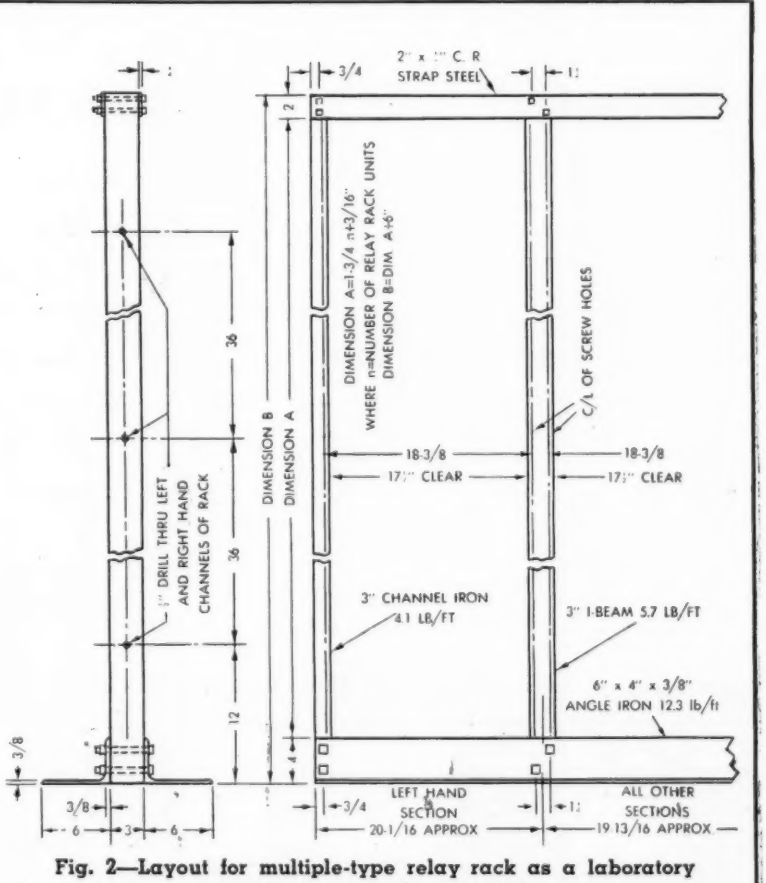


Fig. 2—Layout for multiple-type relay rack as a laboratory equipment support. Design may be modified in one or more sections; for example, for inclusion of distillation and other laboratory or pilot plant equipment

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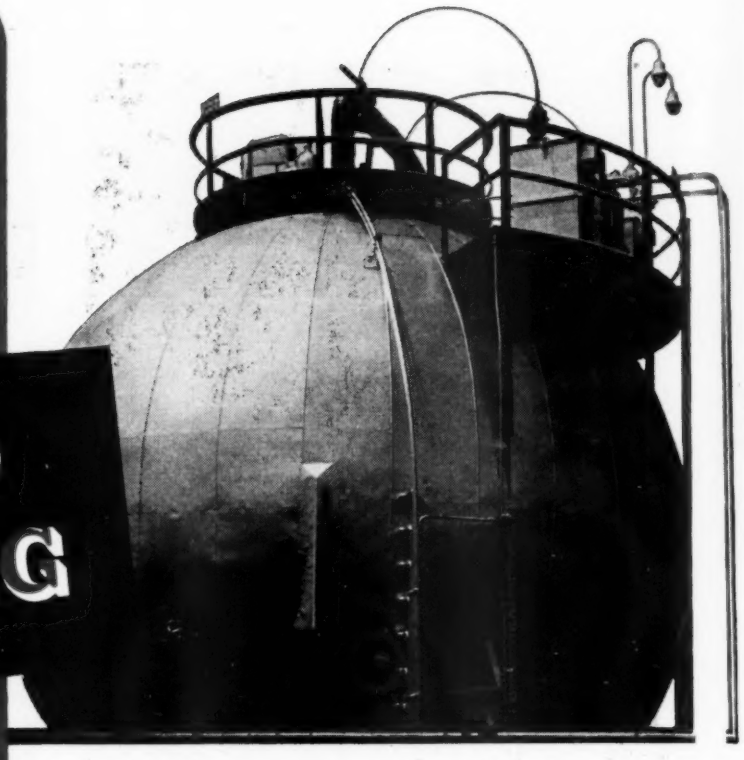

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Corrosion

Reviews of Papers Presented at the 13th Mid-Year Meeting of American Petroleum Institute Division of Refining, Philadelphia, May 10-13, 1948

Prevention of Corrosion in Refinery Heat Exchanger Equipment

By M. A. FURTH, Pure Oil Co., Nederland, Texas

This paper, given in part, discusses corrosion problems as experienced in Pure Oil Co.'s Smiths Bluff refinery at Nederland, Texas. Brief statements concerning the following are included: (1) types of crudes involved, and their relative effects on corrosion, (2) experiences in chemical neutralization of corrosive agents. The foregoing are introductory to: (3) types and effects of corrosion losses in shell-and-tube and submerged-bundle types of heat exchangers, (4) types of metal alloys used to resist corrosion of various exchanger parts, and the methods of application of such alloys.

The paper, under the same title, was presented before the 13th Mid-Year Meeting of the API Refining Division, Philadelphia, May 12, 1948.

CORROSION control is usually effected through such means as: selection of crudes; chemical neutralization; or the use of corrosion-resistant metal alloys. In evaluating the effects of corrosion and the relative value of various methods of control, the type of heat-exchanger equipment must also be considered.

At the Smiths Bluff refinery the two types of heat exchangers in most common use and the relative extent of their usage are:

1. Shell-and-tube — approximately 67 per cent of total installed surface.
2. Submerged bundles in water — approximately 21 per cent of total installed surface.

Shell-and-tube exchangers at this plant are of conventional design. Although there are a few of them using ¾-in.-OD tubes, the plant has standardized on the use of 1-in.-OD, 16-ft. 0-in.-long tubes, arranged on 1¼-in. square pitch. This type of exchanger is being used for condensing, cooling, preheating, reboiling, etc.

The submerged bundles consist of a pair of tube sheets approximately 16 in. wide and 69 in. high, into which from 168 to 228 tubes have been expanded in the same manner as in the tube sheets of a shell-and-tube exchanger. The tubes have been standardized at 1-in.-OD, 14-gage, 22-ft.-long. These bundles are merely set side by side in an open-top water box into which water is introduced.

The most common corrosive agents have been:

a. Sulfur and sulfur compounds.
b. Hydrochloric acid.
c. Organic acids.
d. Ammonia and ammonia compounds.
e. Oxygen.

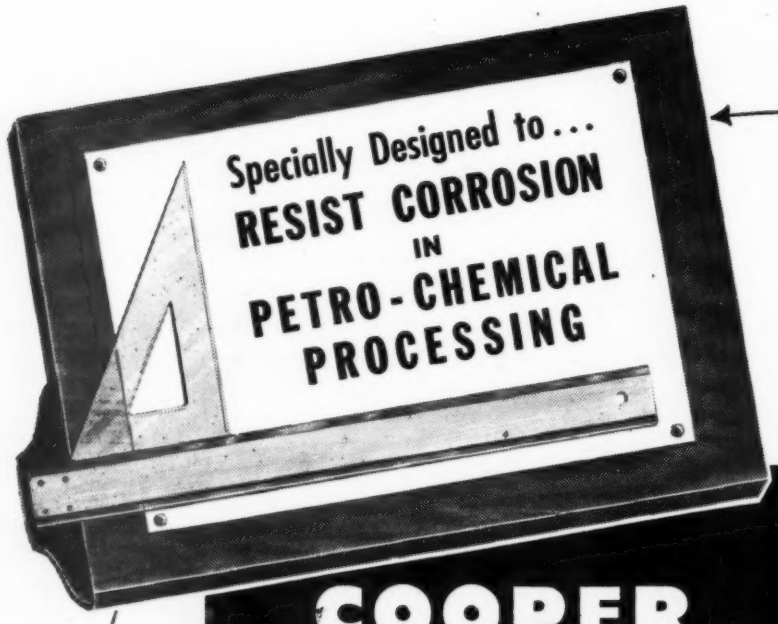
Each of these corrosives behaves differently under different conditions. The problem is further complicated by the fact that corrosion is often due to a combination of several corrosive media and conditions that make it difficult to determine the exact extent for which each corrosive condition is responsible. Different types of crude have been found to cause wide variations in corrosion patterns and rates. In this plant crudes have been generally classified as sweet, East Texas, and Louisiana types.

High-temperature sulfur corrosion, as experienced in heavy cracked distillate recycle systems at temperatures of approximately 675 to 750° F, results in corrosion rates ranging from 0.070 to 0.150 in. per year on carbon steel. The rate, of course, is largely dependent on temperature, velocity and impingement effects; hence the wide variation. The use of 4.0- to 6.0% chromium 0.5% molybdenum alloy (hereafter referred to as 5% chrome-alloy steel) for this service has reduced corrosion rate to a maximum of 0.008 in. per year.

Hydrogen sulfide has been found in minor amounts in straight-run or virgin gasoline and naphtha streams from all sweet crudes. Hydrochloric acid, produced from salts in the crude during processing, has also been found in these same streams. Hydrogen-chloride corrosion has been a severe problem in one unit which is running a crude mix with a maximum salt content of 125 lb. per 1,000 bbl. In this case the corrosion rate on carbon steel has been measured at more than 1.5 in. per year in localized areas. Ammonia injection has been successfully used in reducing this corrosion rate appreciably.

In thermal cracking-unit systems both sulfur compounds and organic acids are found. The latter have been experienced in serious quantities when crudes containing appreciable amounts of esters are processed. These acids are well distributed throughout the streams, but give most trouble in the presence of water and steam. Formic, acetic, proprionic, and butyric acids are present in the gas-handling and gasoline streams. Coupled with hydrogen sulfide, they are a severe corrosion problem in gasoline stabilizers and gas plants.

Ammonia is useful in reducing the attack near points of injection. However, it has been limited in use; because, if sufficient quantities are used to control acid attack, it usual-



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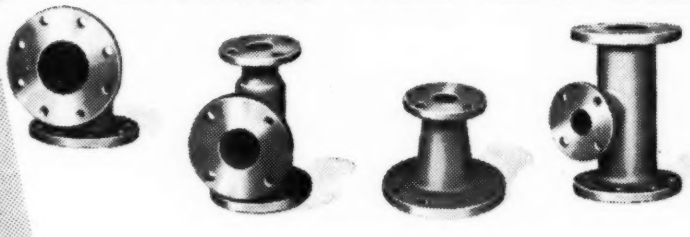

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CF 17 S	C. .07—.10%		
CF 17 SMO	C. .07—.10% Mo. 3%		
CF 17 SCB	C. .07—10% Cb. .70%—1%		
CF 22	Cr. 24—28% Ni. 9 —12% C. .20—.50%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	90,000 psi 60,000 psi 30% 35% 180 .28 lb.
CF 22 S	C. .10% max.		
CF 25-20	Cr. 24—26% Ni. 19—20% C. .20—.30%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	65,000 psi 45,000 psi 22% 25% 180 .29 lb.
CF FA20	Cr. 19—21% No. 28—30% C. Max. .10% Molybdenum 3—4% Silicon 1.5% max. Cu. 4-4.5%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	75,000 psi 45,000 psi 40% 45% 140 .29 lb.
MONEL (MM)	Ni. 67% Cu. 28% Fe. 3% Si. 1%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	65,000 psi 33,000 psi 25% 28% 150 .32 lb.

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ly results in ammonia attack on non-ferrous exchanger tubes at other points in the system.

Caustic washing is a more positive means of removal of these acids when they are present in large quantities. It also must be done at such a location and in such a manner that satisfactory removal of the caustic is accomplished, and so that damage to non-ferrous materials at other points in the system will be prevented.

When a crude mix containing from 25 to 66% Van Zandt crude is run, the amount of acids present in the unstabilized cracked-gasoline stream will require from 31 lb. to 81 lb., respectively, of sodium hydroxide (NaOH) per 1,000 bbl. of gasoline for neutralization. Under such conditions and without neutralization, corrosion rates of 0.068 in. per year are experienced on carbon steel wherever acid waters collect.

In the case of Thermofor catalytic cracking, the corrosives are mainly ammonia and hydrogen sulfide which result from the cracking process. Corrosion from these sources is severe in the gas-plant section, and has led to crack failures of admiralty tubing in condensers, principally in depropanizer and debutanizer systems; 70-30 cupro-nickel tubes are now on trial as an alternate for admiralty which has not been satisfactory in these systems. No data are available at this time. No chemical neutralization has been attempted.

Losses by oxygen are associated with water. The dissolved oxygen content of approximately 7 ppm plus total chlorides (expressed as sodium chloride) of 1,100 ppm of the cooling water is of such proportion as to cause dezincification losses in plain admiralty tubing with water temperatures of from 90 to 150° F. This form of loss was effectively prevented in most cases by the use of either copper alloys with little or no zinc; or admiralty tubing of the inhibited variety, using less than 0.10% of either arsenic, phosphorus, or antimony as the inhibitor.

Similar water, except with salt content varying between 600 and 1,000 ppm, when used for boiler feed water continued to give evidence of very slight dezincification of inhibited admiralty in the temperature range of 150 to 250° F. Tube life was not materially affected, as the controlling factor was corrosion from the process side. The use of soft and deaerated water has completely corrected this situation.

Former heavy losses on water-exposed steel surfaces of feed-water preheaters have also been reduced by the use of softened and deaerated water. The reduction is due to elimination of oxygen pitting. Remaining corrosion losses are principally due to the anodic relationship of steel and iron to copper or brass used for tubes.

Tubes

Tubes are one of the most difficult and expensive of exchanger-parts replacements, at least insofar as labor is concerned. If 1-in.-OD, 12-gage, 16-ft.-long steel tubes and 1-in.-OD, 14-gage, 16-ft.-long inhibited admiralty tubes are used, the labor cost of removal and replacement usually runs in the neighborhood of $1.25 and $1.00 per tube, respectively. This is equivalent to 30 cents and 24 cents per square foot of exchanger surface for the 2 respective types of metals.

For condensing and cooling service, with water as the coolant, inhibited admiralty has been adequate except where ammonia and hydrogen sulfide are present in such quantities and under such conditions as to promote stress corrosion or corrosion-fatigue failures; 70-30 cupro-nickel tubes are now on trial at such points. In one case the trial is now a year old with no evidence of cracking, although the corrosion rate is apparently greater. Based on comparative metal costs, an increase of approximately one-third in tube life will be required to justify using the more expensive alloy.

Carbon steel is the basic material for the oil-to-oil exchanger service. In cases in which hydrochloric or organic acids have been involved, admiralty metal has sometimes proved to be preferable. In the case of high-temperature sulfur corrosion (range 650 to 900° F) 5% chrome-alloy-steel tubes are used successfully, and have a service life several times that of carbon steel. Use of this alloy will result in a cost increase of 110% as compared with carbon steel, or approximately $1.00 per square foot of retubed bundle surface.

Basic material for water service has been naval bronze. Current practices include carbon-steel tube sheets with non-ferrous facings.

Naval bronze, or other non-ferrous material, is not particularly well adapted to retubing under field conditions because of the ease with which the metal deforms. While tubes are expanded into the sheet, very good control is required if over-expansion and consequent tube-sheet deformation are to be avoided. In some cases of field retubing, sheet diameters have been increased as much as ¼ in., with visible distortion of the face.

Steel Has Greater Strength

Steel is preferred because of its greater strength, which strength permits thinner tube sheets to be used, and it also permits a greater number of retubings. Steel tube sheets have been adapted to water service with non-ferrous tubes, using several techniques—with varying results as follows:

1. Plain carbon-steel tube sheets with admiralty tubes have been found moderately successful where considerable corrosion allowance can be left on the water side and where no pass gasketing is required. The ratio and proximity of exposed areas of admiralty and steel are such that electrolytic attack is serious—with losses running up to ⅜ in. deep, in annular pits around tubes—within 2 years' time. Under these circumstances gasket surfaces for pass baffling become seriously impaired by undermining (see Fig. 1-A).

2. Paints have been tried with no success.

3. Tinning has been a failure, because of pin holes which allow corrosion to start and then blister off the solder coat.

4. First attempts at acetylene-torch-brazed surfacing were unsuccessful because of the unfortunate selection of high-zinc materials which resulted in serious and rapid dezinci-

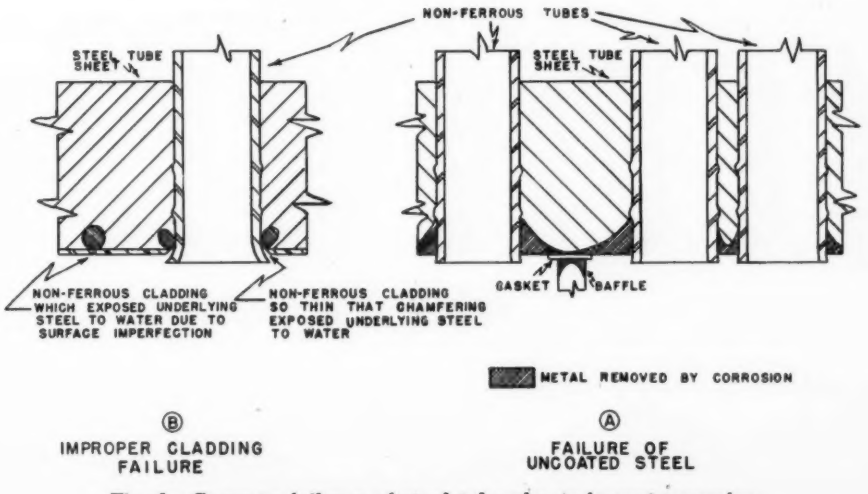

NON-FERROUS TUBES
STEEL TUBE SHEET
STEEL TUBE SHEET
GASKET
BAFFLE
NON-FERROUS CLADDING WHICH EXPOSED UNDERLYING STEEL TO WATER DUE TO SURFACE IMPERFECTION
NON-FERROUS CLADDING SO THIN THAT CHAMFERING EXPOSED UNDERLYING STEEL TO WATER
METAL REMOVED BY CORROSION
Ⓑ IMPROPER CLADDING FAILURE
Ⓐ FAILURE OF UNCOATED STEEL

Fig. 1—Common failures of steel tube sheets in water service

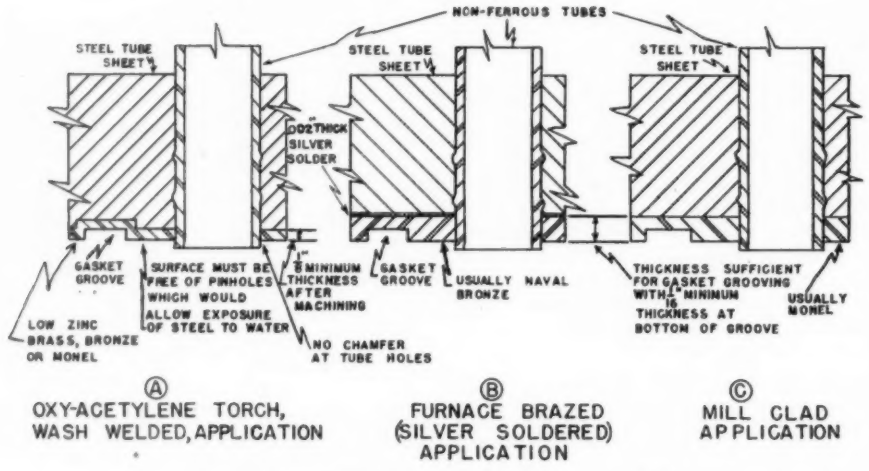

NON-FERROUS TUBES
STEEL TUBE SHEET
STEEL TUBE SHEET
STEEL TUBE SHEET
.002" THICK SILVER SOLDER
GASKET GROOVE
SURFACE MUST BE FREE OF PINHOLES WHICH WOULD ALLOW EXPOSURE OF STEEL TO WATER
1/8" MINIMUM THICKNESS AFTER MACHINING
GASKET GROOVE
USUALLY NAVAL BRONZE
THICKNESS SUFFICIENT FOR GASKET GROOVING WITH 1/8" MINIMUM THICKNESS AT BOTTOM OF GROOVE
USUALLY MONEL
LOW ZINC BRASS, BRONZE OR MONEL
NO CHAMFER AT TUBE HOLES
Ⓐ
OXY-ACETYLENE TORCH, WASH WELDED, APPLICATION
Ⓑ
FURNACE BRAZED (SILVER SOLDERED) APPLICATION
Ⓒ
MILL CLAD APPLICATION

Fig. 2—Alternative types of non-ferrous cladding

fication. Surfacing so affected spalled off.

5. Next attempts utilized low-zinc (16% or less) brazing rods with good results, at least insofar as dezincification was concerned. However tube-sheet life was seriously impaired and limited by large voids which were corroded in the steel (under the bronze) by electrolytic means. The fault lay in a bronze deposit of insufficient thickness, which in some cases included pin holes. Tiny annular areas of steel were exposed around tubes where chamfering had removed the bronze, or at the bottom of the pin holes through the bronze. The unfavorable relationship of steel and brass areas exposed to the electrolyte led to extremely damaging losses under the brass surfacing (see Fig. 1-B).

6. Successfully brazed surfaces have been accomplished by careful oxy-acetylene application of low-zinc bronze in sufficient thickness to allow final machining with a minimum bronze thickness of ⅛ in. at the tube holes. Chamfering is omitted. The tube, when expanded, seals off the underlying steel from contact with the electrolyte (see Fig. 2-A).

Based on 2-in. total thickness, the cost of both tube sheets clad by this method will run close to 90 cents per square foot of exchanger surface (based on 1-in.-OD, 16-ft.-long tubes on 1¼-in. square pitch). Solid naval bronze would cost 70 cents under the same conditions.

7. Monel-clad steel plates of the mill-clad variety have also beeen successfully used, although the extent of usage has been insufficient to determine service temperature limits (see Fig. 2-C). Cost is usually 68 cents per square foot of exchanger surface, with conditions the same as in case (6) above.

8. As another successful alternate, naval-bronze plates have been furnace-silver-soldered to steel sheets, as shown in Fig. 2-B. This work is being done in a Gulf Coast exchanger-maintenance shop at a cost of 69 cents, which compares favorably with monel mill cladding [see case (7)] and can be produced with very favorable delivery time. This type of sheet has been used with gratifying results when metal temperatures are 400° F. or lower. High temperatures are associated with excessive differential expansion and subsequent failure of the bond between bronze and steel.

9. Monel-clad by welding: The method which has been used most extensively consists of depositing monel on steel tube sheets, using welding as a means of applying monel. The steel tube sheet is prepared by machining the sheet to a true plane, cutting all grooves for gaskets and pass ribs ¼ in. wider and ⅛ in. deeper than required in the finished tube sheet. Usually 3 passes of weld metal are applied which are of sufficient thickness to allow ⅛ in. of monel over all surfaces after machining.

To facilitate good penetration and a high-quality weld, it has been found desirable to apply the first pass using pure nickel electrodes—the two subsequent passes using monel electrodes.

The tube sheet is machined to a true surface, and any defects are repaired before drilling the tube holes. Tube sheets prepared by this method are less costly than non-ferrous sheets of equal design strength, and will withstand more retubings without distortion than non-ferrous tube sheets.

Tube Sheets for Hydrocarbon Service

For all except the most severely corrosive hydrocarbon service, plain carbon-steel tube sheets are used with appropriate corrosion allowances applied to the thickness. Tongue-and-groove gasket joints are used with the groove in the tube sheet. The gasket grooves usually retain a good bottom surface because of the protection afforded them by the walls of the groove. Occasionally, however, they become damaged by corrosion or abuse, and repair is necessary. Remachining is possible without removal of the tube sheets from the bundle, and subsequent retubing by the use of a horizontal boring mill which is sized to handle the largest bundle in the refinery.

When bundles are retubed and rebuilt, the tube sheets are inspected to determine if remachining of gasket surfaces is required. If refinishing is necessary, these surfaces are remachined in an alloy-weld overlay, usually of 25-20 AISI* type No. 310 chrome-nickel, or chrome-nickel-molybdenum AISI type No. 316 stainless steel. Both of these metals are well adapted to high-temperature sulfur corrosion, with the latter being also applicable where organic acids are bothersome. Monel, as well as type No. 316 stainless steel, has been used for resistance to hydrochloric-acid corrosion.

Completely new exchangers or bundles for services involving unusually corrosive conditions are sometimes equipped with full alloy wash-welded clad tube sheets. The chrome-nickel stainless steels are well adapted to this kind of work. The most frequent choice is 25-20 AISI type No. 310 because of its excellent corrosion resistance to most refinery

* AISI = American Iron and Steel Inst.

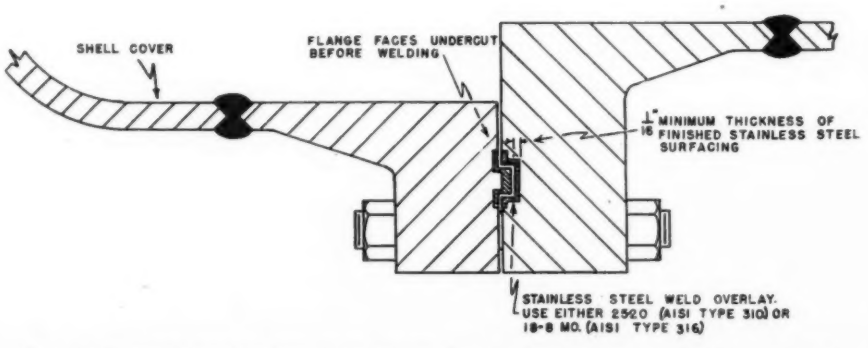
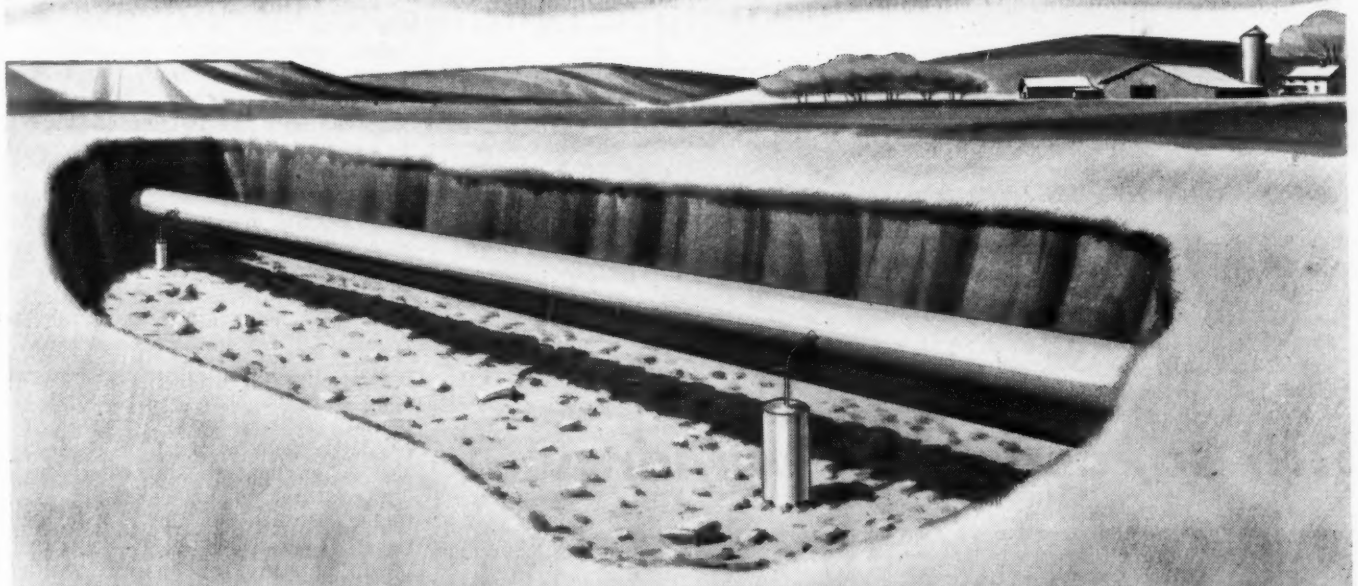

SHELL COVER
FLANGE FACES UNDERCUT BEFORE WELDING
1/16" MINIMUM THICKNESS OF FINISHED STAINLESS STEEL SURFACING
STAINLESS STEEL WELD OVERLAY. USE EITHER 25-20 (AISI TYPE 310) OR 18-8 MO. (AISI TYPE 316)

Fig. 3—Typical application of stainless steel facing to flange gasket surfaces

CORROSION CONTROL



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corrosives, and because of its excellent machinability.

As in the case of tube sheets and tubes, replacement of transverse baffling cannot be made without complete retubing of the bundle. This involves an expense far beyond the cost of the baffles alone.

Carbon steel is ordinarily used, provided reasonable thickness of from ¼ to ½ in. are sufficient for at least the life of the tubes at the corrosion rate involved.

The baffles, although exposed to the same fluid as the outside of the tubes, are ordinarily corroded at a more rapid rate. Both surfaces of the baffles are exposed and affected, whereas only the outside of the tube is exposed; also the baffle temperature more nearly approaches the shell-side fluid temperature. When the heating medium is on the shell side and is corrosive at high temperatures, the penetration rate for the baffles will generally be greater than the penetration rate for the tubes when the materials are alike.

Both 18-8 stainless and 5-per-cent-chrome steels have been used economically where heavy cracked distillate recycle is used on the shell side of preheaters and where high-temperature sulfur corrosion is a factor. Bronze has also been used to resist hydrochloric-acid attack in virgin naphtha condensers.

Shell and Shell Cover

Although welded alloy-steel shells are available, Smiths Bluff refinery has used plain carbon steel to date. Corrosion allowances up to ⅛ in. have been applied to the thickness. Greater allowances would ordinarily be of no value, as the exchanger efficiency would be reduced by bypassing to such an extent that full use of the corrosion allowance could seldom be realized.

Localized alloy wash-welding with 25-20 chrome-nickel rod has been resorted to in a few cases. The cost of deposited metal is such as to make it an undesirable method of large-scale protection. The use of alloy strip lining has been confined to more or less emergency repairs. Such liners utilize 3-in. or 4-in. wide strips of 12-to 14-gage alloy steel, such as 18.8 molybdenum type No. 316, or 11½- to 13-per cent chrome type No. 410 (maximum carbon, 0.08 per cent), applied to the shell by electric welding at the edges of the strip with 25-20 chrome nickel welding rod. Although costs of from $8 to $14 per square foot are possible, the method is not favored because of the possibility of liner failure and subsequent interference with free passage of the transverse baffles and floating tube sheet when removing the tube bundle.

Shell flanges are used with tongue-

and-groove gasket-joint construction. Mechanical handling, as well as corrosion, often damages the gasket seating surface. Remachining is accomplished by use of a portable facing tool after the surface has been built up by welding. Costs are usually in the neighborhood of from $60 to $70 per foot of diameter; 25-20 chrome-nickel or 18-8 molybdenum stainless-steel welding rod is always used instead of carbon steel for this work, because the material cost is only a minor part of the total job cost. Subsequent corrosion troubles are thereby eliminated.

Fig. 3 illustrates the application of alloy to gasket surfaces.

A Resume of Sohio's Experience In Overhead Condensing Equipment

By E. N. SALATHE, Standard Oil Co. (Ohio), Cleveland, Ohio

A REVIEW of the paper under the same title, presented before the 13th Mid-Year Meeting of the API Refining Division, Philadelphia, May 12, 1948.

DETAILED inspection and operating records of various processing units at the No. 1 refinery have provided Sohio with valuable data with which to evaluate and properly choose the most satisfactory kinds of materials of construction for overhead condensing equipment. These records have been kept since 1938 in the case of the exchangers on a battery of shell stills; and since 1944 for condenser stacks on Houdry catalytic cracking units and on heat transfer equipment in the liquefied gas plant. Other units on which information has been of help are the thermal cracking plant and the catalytic polymerization units.

Original installation in the case of the old shell stills were cast-iron shells and steel tubes. These were later replaced with carbon steel or inhibited admiralty tubes and steel shells. Service life lengths have ranged from 10 to as high as 49 months.

Satisfactory remedial measures for prevention of corrosion in this equipment have been obtained through regulating the pH of the system. This is accomplished by withdrawing a continuous sample of the aqueous condensate from a reflux accumulator of each still in the battery and running it through a pH recorder. Adjustments to control the pH are then made by ammonia injection with rotameters to maintain a pH ranging from 6.8 to 7.2.

As in the case of the crude stills, corrosion has been found to be greatly influenced by pH also in the case of the Houdry unit condenser stacks. Early records showed that pH varied from a minimum of 4.8 to a maximum of 8.8 during each 20-minute cycle in the process.

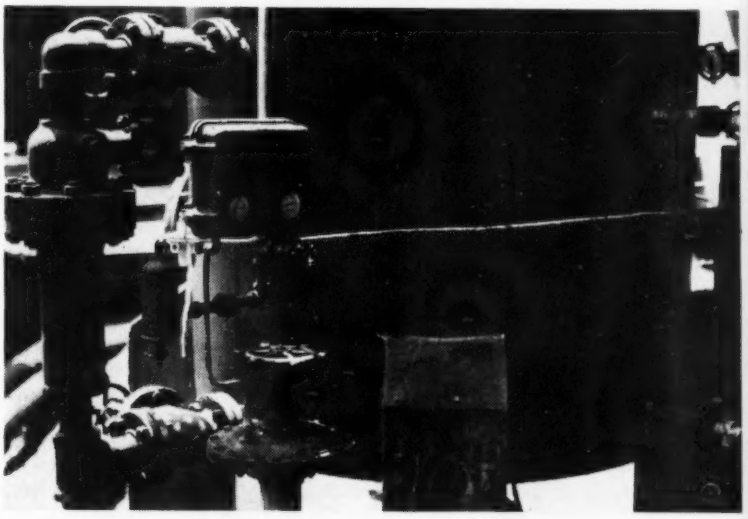
Original materials for bundles was carbon steel, which began to show signs of failure within six weeks of initial start-up. Frequent replacements have been made, the major portion of which have been with the inhibited admiralty material. Efforts to date to help combat corrosion at this point have been to remove as rapidly as possible the excessive sulfur deposits. This has been done by water washing.

Similar remedies were used in the liquefied gas plant. A centrifix was installed in the suction line to the gas compressor stream, immediately adjacent to the suction knockout drum. "At this point we found that it was possible to remove a large quantity of entrained material by the action of the surge drum," the paper states, "and that the rest of the materials could be removed by centrifixing and water washing.

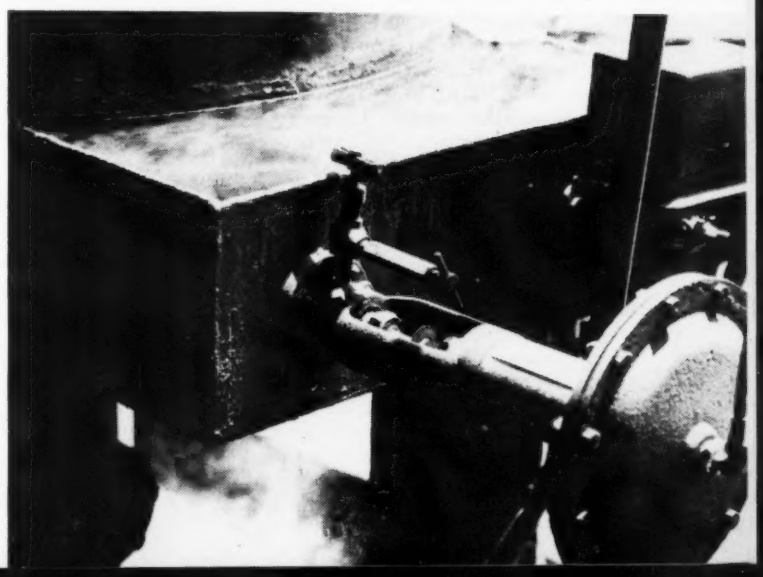
"This installation accomplished two purposes: (1) corrosive materials were removed before they entered the gas compressors, thereby eliminating a high percentage of the clogging of the compressors caused by sulfur compounds and, in addition, providing (2) a much drier and cleaner gas for processing."

An interesting method of fighting corrosion in the open-box condensers on the thermal cracking units has been the use of cathodic protection devices. Initial installation of these devices was completed about four years ago, and Sohio feels results have been very satisfactory.

Changing to a different material apparently has been an answer to the problem of handling dilute phosphoric acids in the catalytic polymerization unit. The acid condition is the result of contacting a butane-butylene feed stock with phosphoric acid catalyst. Cooler bundles originally made of inhibited admiralty material have been replaced with 18-8 chrome nickel alloy. Reboiler bundles originally of carbon steel have been replaced with admiralty.



Corrosion control on crude still reflux drum. Continuous sample of the aqueous condensate is run through a pH recorder



Water box and calomel electrode on crude still reflux drum. Sohio has found careful control of pH at this point a good remedial measure toward the prevention of corrosion

Training

Reviews of Papers Presented at the 13th Mid-Year Meeting of American Petroleum Institute Division of Refining, Philadelphia, May 10-13, 1948

TRAINING OF PROCESS OPERATORS

By H. A. LUTZ and C. P. BAKER
Socony-Vacuum Oil Co., Inc., East St. Louis, Ill.

Control standards and an operating manual for individual processing units were worked up at the East St. Louis refinery of Socony-Vacuum Oil Co., Inc., as features of a training program for process operators. The standards set up, among other data, control points for variable factors for economic normal operations. Summary sheets filled out by operators for each 24 hours' operations give the actual data on control points, which provide for a quick evaluation of the unit.

The manual includes a general description of the operation of the unit, normal startup and shutdown and a description of the mechanical equipment. Operators are familiarized with the control standard and manual through discussion meetings at which their questions are encouraged. Definite improvement in operation of the various units has resulted from the program. The accompanying is a principal portion of the paper as presented.

PRIOR to 1946 training of new employes at the East St. Louis refinery of Socony-Vacuum Oil Co., Inc., was accomplished by having experienced personnel assist in breaking them in on the job. Before the start of the Houdry unit some of the process operators had acquired some breaking in on similar units in other company refineries, and also had obtained some knowledge from short manuals prepared from information furnished by other company units.

Before the TCC and the alkylation units went on stream, process operators had journeyed to other refineries for operating knowledge and had read correspondence pertaining to experiences with these units. This training, although limited, was valuable.

Operating conditions for the units were established prior to 1946 in discussions by various members of plant management, although not always by all those directly concerned. Instructions usually were passed to the operators by word of mouth or by entry in the daily operating log books located at each unit. The shortcomings and inadequacies of such a method, especially with inexperienced refinery personnel, were evident because instructions could be misunderstood; or, if they had been placed in the log book, they could not be readily found and consulted.

In January, 1946, the refinery manager recommended the use of written operating standards for stabilizing refinery operations. These standards were to contain established points of control, and copies were to be issued to the operating personnel. These standards were also to include a description of the method to be used for maintaining these points. It was evident that the proposed operating standards should help stabilize refinery operations.

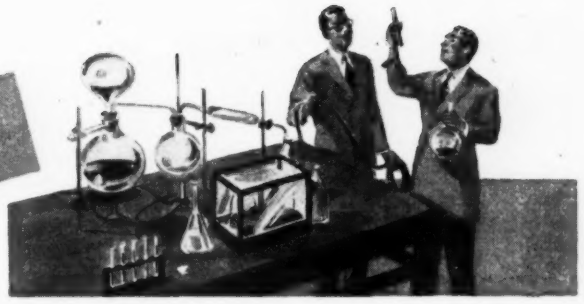
However, inasmuch as trained personnel is essential for efficient operations, a more extensive program was required. Approval for the additional training was readily obtained, and work was started on an operating manual that would describe in detail the refinery operations and equipment. The idea primarily was to take the mystery out of the jobs and to let the men know what they were doing and *why*.

The preparation of the operating standards and manual was assigned to the refinery technical division. The information was to be supplied by the various refinery divisions, viz., operating, maintenance, laboratory, engineering, and industrial relations. Before issuance, each section was to be approved by the operating division, the technical division, and the refinery manager.

In cooperation with the operating-division department managers, the technical personnel collected data and accomplished other necessary work essential to the writing of the operating standards. The department manager gave the first set of standards to the process operators of the crude unit for the purpose of finding out how the personnel would accept and react to them. Once in use, the minor shortcomings of these standards were noted; and the cooperation of those responsible for the operations resulted in improvements which are still being made for more efficient operations.

The operating conditions, as specified in the operating standards, were to be followed during normal operation. It was expected that abnormal conditions would arise and that temporarily the unit could not be operated within the limits as specified in the operating standards. As soon as these conditions could be corrected, it was expected that the control of variables would again be governed by the operating standards.

The operating manual as originally planned was to contain: 1, a brief history of petroleum and refining; 2, a brief history of the Socony-Vacuum company; and 3, a description of each

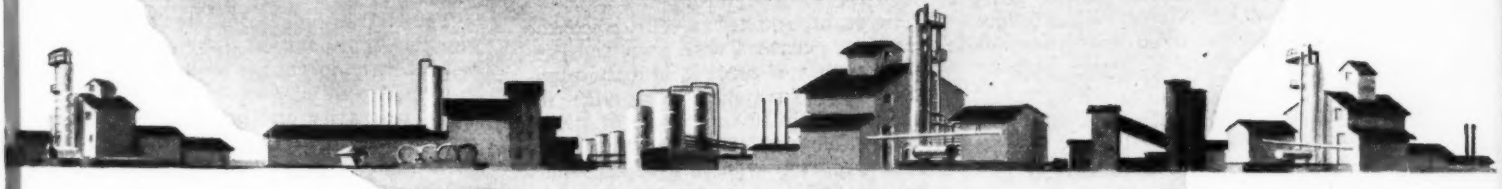


THE TESTS ARE MADE

PREMIUM QUALITY ASSURED

THE PLANS ARE FINISHED

IT'S DECIDED



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operating unit. Operating-unit descriptions were to include a general summary of the operation of each unit, the normal startup and shutdown procedure, and a detailed description of the mechanical equipment on the unit.

The completion of the operating standards and a general description for each unit were scheduled to appear in advance of the other parts of the manual because collection and publication of the balance of the information would require considerable time.

The general description of the crude unit was issued with the operating standards, in the spring of 1946, as the first section of the operating manual. This consisted of flow diagrams, with explanations of the various sources of feed, to the unit as well as the disposition of the products. Some practical theory of fractionator operation was also included.

Improved Knowledge of Operations

These first attempts to establish operating standards and an operating manual disclosed many new and worthwhile ideas. With this attempt to issue practical operating standards the technical personnel gained a much better practical knowledge of operations. Desirable points of control—which some refinery groups had previously not considered critical, but which others considered essential for efficient operations — were established.

In brief, the operating experience and technical background of all refinery personnel were combined so as more nearly to approach the most economic, safe, and otherwise desirable methods of operation. This information was then issued as a printed manual, in one binder, to the personnel who supervise and operate the equipment.

From the work on the crude unit, the program moved to the other refinery units. Because of past performances on the TCC unit, considerable time was spent in the preparation of standards and on an operating manual for this unit. In addition to the general description, the manual included some theory of catalyst flow —a new principle. For a thorough understanding of operations, therefore, it was felt that some idea of the engineering that had gone into the unit was desirable. Special equipment on the unit, as well as the complicated controls, were discussed in detail. Pump curves, showing the capacity at various heads and the power required of the prime mover, were also incorporated.

Management took the view that any information which the process operator needed or would find of interest should be supplied. It was felt that operators frequently react as they do because they are not furnished with sufficient information. Also, this was an attempt to prove to the operator that management is more than willing to do its part in the achievement of desirable and efficient operation.

When the operating standards had been issued for a specific unit, a form was prepared. When filled out by that unit, it constitutes a summary of the previous 24 hours' operation. In addition to the control points, these sheets show an average of other operating conditions and provide for remarks on the unit's performance. (Fig. 1 shows a typical summary sheet).

These summary sheets are filled in each morning about 6 a.m. by the process operator and forwarded to the technical and engineering division, where they are checked for points off-standard. Duplicate copies are sent to the department manager, the operating superintendent, the technical and engineering-division manager, and the refinery manager. This sheet allows a quick evaluation of the unit's previous 24-hour operation, and also furnishes a continuous history of the operation for ready reference. The remarks on the summary sheet may initiate some immediate work to be done by refinery personnel not directly concerned with the unit's operation.

The standards having furnished the process operator with written required points of control, and the manual having furnished him with information helpful to the maintenance of desirable operation, the next step in the program was to give the operator a definite opportunity to express his opinions and ask any questions he might have in mind, as well as to present to him further information which could not be included in the manual.

Hold Discussion Meetings

Discussion meetings were periodically scheduled for the stillmen and operators, the two highest brackets in the operating division. These men are paid for their attendance at overtime rates. Firemen and utility men or any other refinery personnel are welcome to attend the meetings on their own time. Two meetings on the same subject are necessary to cover the personnel assigned to one unit, and from 10 to 20 individuals attend each meeting.

These discussion groups are planned and conducted by the operating and technical divisions. The programs to date have included discussions on the operating standards and manuals; why control points were established; and other data which have resulted in the written work. Motion pictures and talks by specialists—such as electrical, mechanical, and instrument engineers—have also been programmed.

During these discussions the process operator is urged to ask questions and if the answers are not readily available every effort is made to obtain and supply them. A definite attempt is made to present information which can easily be accepted by the process operator rather than to give highly technical information not readily understood.

It should be appreciated that the foregoing program cannot be accomplished without cost. It should also be emphasized that the cost is a continuing one, for new people are being brought into operations from time to time who require access to the same training currently going on. That there has been no question to date as to the benefit derived can be seen by reference to a few simple points regarding the improvements in the crude unit operation.

Top Crude Throughput Increased

In 1946, after the establishment of the training program (including standards), crude throughout averaged in excess of 22,500 b/d (calendar). In 1945, 21,000 b/d had been considered top operation. The kerosine yield from the same crude unit averaged 3,000 b/d in 1946, whereas previous operations had produced less than 2,500 b/d and this was considered efficient.

The 90% point of the straight-run gasoline controlled by laboratory tests—with operators making adjustments depending on laboratory results, primarily on the basis of their own judgment—had varied more than 20° F. from day to day. Following the establishment of standards and proper training of the operator, the 90% point of the straight-run gasoline varied less than 6° F., and the control points were the temperature and pressure at the top of the tower rather than the result of laboratory tests. Other points in the unit's operation exhibited similar improvement over previous results.

Such a program has to be made attractive in order to gain the confidence and backing of the refinery personnel. Our observation is that the program to date is well received by the operating personnel not only in the hourly classification, but also the supervisory brackets. The program has increased the employe's interest by giving him a better understanding of the units and of his job. His questions are being answered, and it is obvious that the plan stimulates employe thinking which, in turn, tends to increase his feeling of responsibility, and to aid him in recognition of the fact that he and his job play an important part in the operations of the refinery.

Incidentally, the availability of the information in manual form to the maintenance foremen has increased

their appreciation of the importance of the work they are requested to do, and has improved measurably the co-operation necessary between operating and maintenance personnel to schedule maintenance work properly.

Another indirect advantage has accrued from the fact that operating personnel from outside plants are from time to time sent to the East St. Louis refinery for training in catalytic cracking. The data available in manual form have materially decreased the time required to train these guests adequately.

As time permits, training at the lower levels is expected to be added to our program in order to give fundamental training to persons newly assigned to pump and valve operation, as well as training in techniques of firing, housekeeping, safety, and other items; so that these persons will have a better foundation for advancement and a greater appreciation for their responsibilities as they advance.

FIG. 1–DAILY SUMMARY SHEET FOR CRUDE UNIT

Average for 24 Hrs.
Ending 6:00 A.M. 2/11/48

Date Heater Fired 12/19/47 Days on Stream 55

FLOW (METER READINGS)

Crude to Heater	8140	B/D	S.R. Gaso. Prod.	5920	B /h
Crude to TCC Exch.	8370	"	S.R. Gaso. Reflux	8140	"
Crude to #1 V.B.	Down	"	Light Naph. to D.F.O.	430	B/D
Crude to #1 V.P.	2696	"	Light Naph. to Kerosene	255	"
Crude to #2 V.P.	2496	"	Light Naph. to Gas Plant		"
Total Crude	21702	"	Total Light Naphtha	693	"
Red. Crude to TCC	12282	B/D	Heavy Naph. to Treater	3012	B/D
R.C. or Tar to #2 V.B.	Down	"	Heavy Naph. to		"
R.C. or Tar to #1 V.P.	738	"	Heavy Naph. to Abs. Plt.	19.5	"
R.C. or Tar to #2 V.P.	1809	"	Total Heavy Naph.	3031.5	"

TEMPERATURES

Crude from Therm. Units	505	°F	Heavy Naph. Leaving Cooler	140	°F
Crude from TCC Unit	508 (X)	"	Light Naph. Leaving Cooler	140	"
Crude from Heater	526	"	Accumulator Temp.	110	"
Crude Tower Bottom	485	"	6:00 a.m. Crude Temp.(PT.10)	42	"
Crude Tower Flash Sec.	503	"	Water From H.Naph.Cooler (W)	135	"
Top Tower Temp.	288	"	Water from H.Naph.Cooler (E)	133	"

OPERATING CONDITIONS

Steam to Bubble Twr.	3078	#/Hr.	Press. on Accum.	6.0	psi
Steam to Light Naph.Strip.	220	"	Top Tower Press.	19.2	"
Steam to Heavy Naph.Strip.	525	"	Flash Zone Press.	20.9	"
Ammonia to Tower	23.1	Day	Bto. Tower Press.	21.9	"
Caustic Solution	7.5		P thru Furnace	150	"

PRODUCT INSPECTIONS

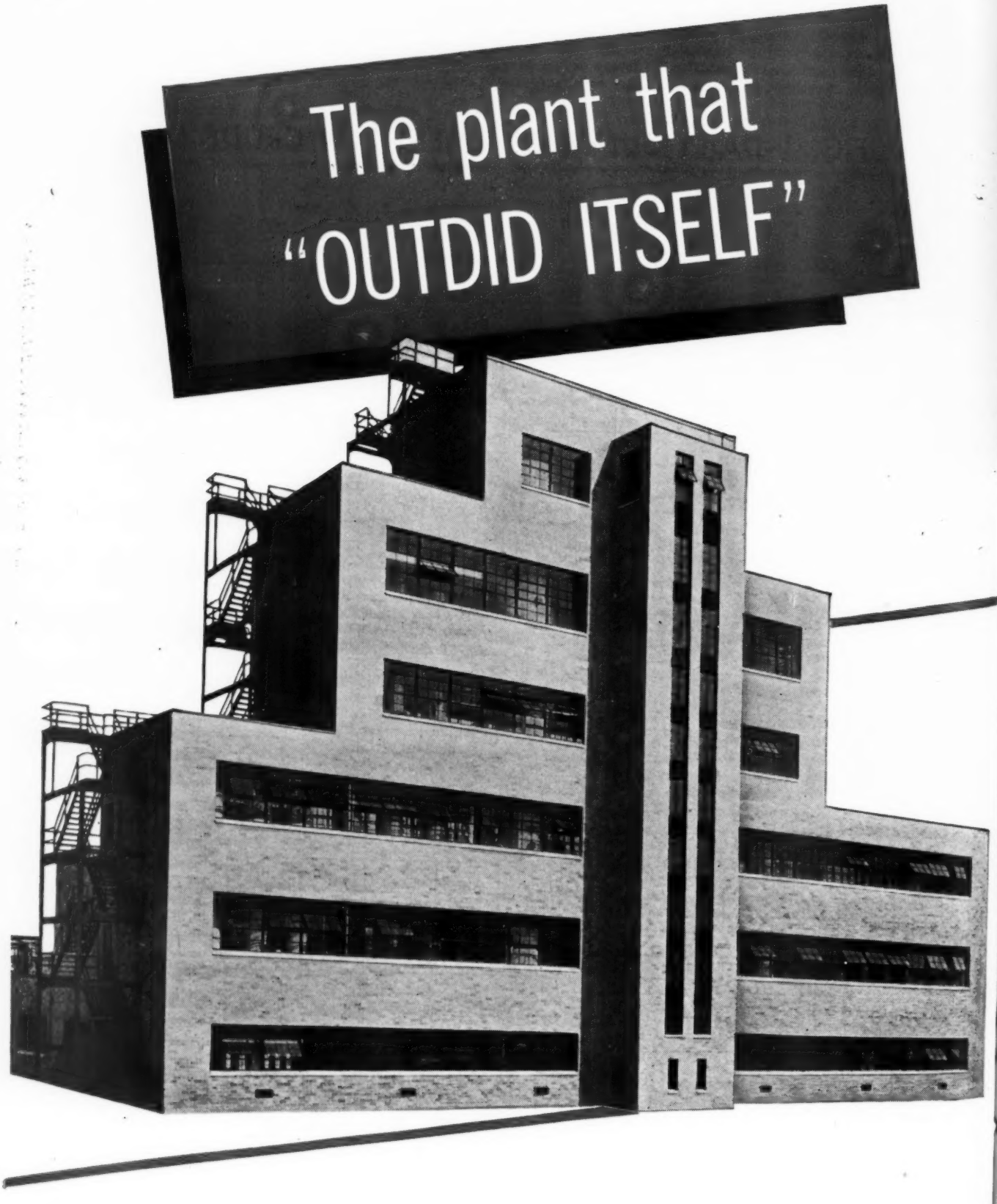
	(API Gr.)	10%	50%	90%	E.P.	Fl.	Color	R.V.P.
Stab. S.R. Gaso.	67.1	147	229	309	343		↓ 30	12.6
Light Naphtha	48.5	333	347	373	403	110	↓ 30	
Heavy Naphtha	43.0	385	435	499	527	128	↓ 30	
Kerosene	43.2	379	431	498	525	126	↓ 30	
Red. Crude	26.7							

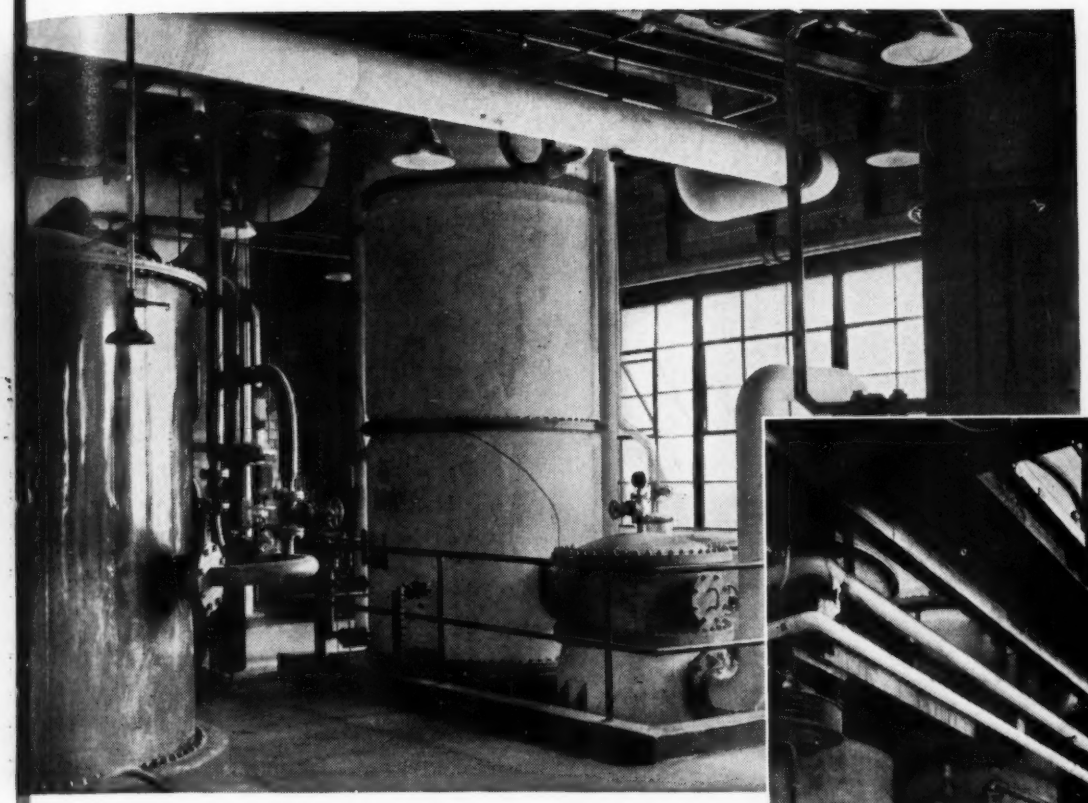
MISCELLANEOUS

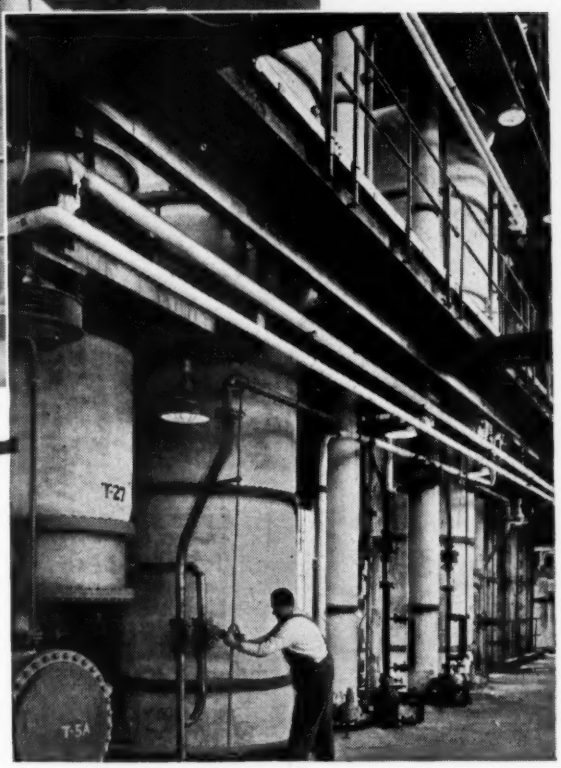
Charge from Tank No. 213 (-1)

H. Naph.	90%	498	489	499
U. Kero.F.		124	123	126

Summary sheet above gives average data for control points, to show if unit performance is up to normal operating standards set up for process operators. (Check X shows deviation at one point as is noted under the Miscellaneous heading)


The plant that
"OUTDID ITSELF"





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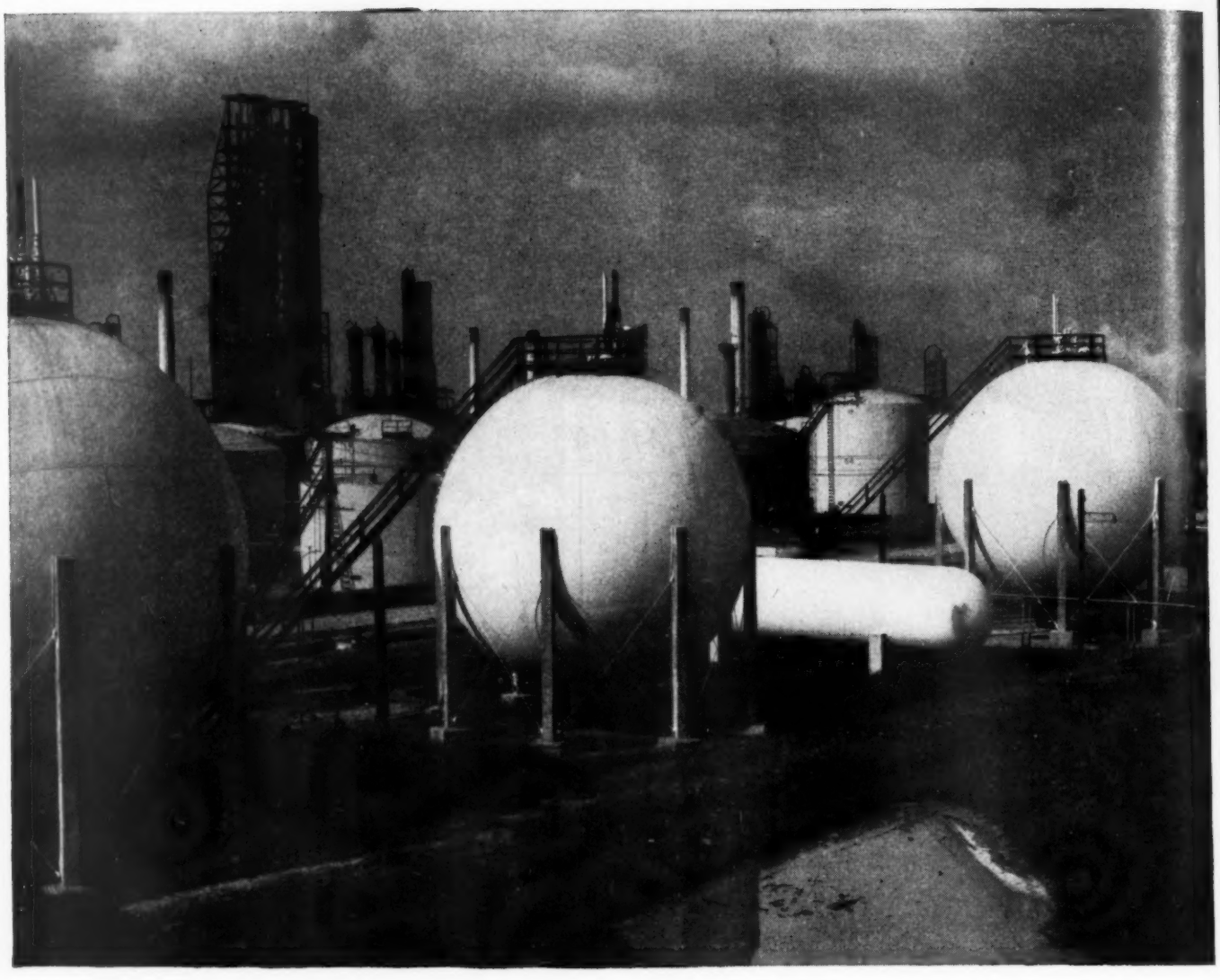

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Determining Refinery Training Needs

A REVIEW of a paper of the same title presented by A. H. Houseknecht, Training Division, Esso Standard Oil Co., at the 13th Mid-Year Meeting of the API Division of Refining, Philadelphia, May 12.

DETERMINING training needs is quite generally accepted as the first step in establishing any organized training activity.

The actual determination of training needs is an evaluation process—a weighing of the performance of the work force or an employee against recognized work requirements. The difference between what is expected or desired and present performance represents training needs.

Spotting a training need and tracing it to one or more individuals requires four successive operations: (1) spot the operating or management problems where training may be required, (2) analyze each problem to determine what part may be solved by training, (3) trace the training need to specific groups of employees, and (4) determine the individual training needs.

In spotting the operating or management problem where training may be required, it is necessary to recognize those problems which present symptoms of training needs. Some such problems indicate obvious training needs, such as new or transferred employees, expanded operations, high accident rate, or excessive re-work. In others the need is hidden and sometimes mistaken for other causes—production bottlenecks, excessive overtime, high maintenance costs, or numerous grievances and complaints.

The analysis of the problem should be made with a great deal of care so as not to miss important facts that may have bearing on the causes or methods for solving the problem. This analysis will require a discussion of the problem with field supervisors, department heads, key employees and others having any knowledge of contributing factors to the problem. Records and reports should be examined to get comparative data; inspections made of operations, supervision and performance routine to check for gaps between recognized standards of operation and performance and existing conditions.

To trace the training needs down to definite groups of employees, a new technique was designed in the form of a Personnel Status Survey. This survey presents a systematic approach for informally analyzing the performance and potential of each employee, and for charting his probable status and development during the ensuing five years. From this survey it is possible to determine (1) the number of employees to be retired in the next five years (and not economically susceptible to training), (2) the number of fully qualified employees in each job classification who are trainable for higher levels of skill or promotion, (3) the number who are deficient in some respect and require improvement training to attain desired work standards, and (4) the number who possess limited potential for the improvement of their skill and performance.

The final operation of determining individual training needs can be accomplished in a sequence of four successive steps:

1) Identify the jobs or work processes in the shop, unit or job classification that must be performed by individual workers.

2) Establish standards of performance for the various jobs or work processes.

3) Evaluate the individual worker's ability to perform the jobs or work processes as required.

4) Record those jobs or work processes in which the individual needs training to perform at desired standards.

As a basis for setting up a simple plan for determining and scheduling specific training needs, Esso found the Job Training Schedule shown in Fig. 1 very effective. This schedule lists in the left-hand column the job requirements for each classification, starting with the highest. They may be specified as skills, machines operated, work assignments, tasks or operations.

Across the top of the form are listed the names of employees by classifications.

The performance of each employee is measured against the previously established standards, the results being indicated by check mark. By reviewing the form horizontally it is possible to detect those job requirements which are under-manned. By reviewing the form vertically, it is possible to spot those employees who have many job deficiencies and need extensive training.

From this point it is relatively easy to identify the job requirements on which each employee requires training, establish priorities for training, and set starting dates for the first employees to be enrolled.

JOB TRAINING SCHEDULE

ACTIVITY: MACHINE SHOP
DATE: 5/7/48 | PREPARED BY: H. Jones - Foreman

LEGEND
- ✓ PERFORMANCE SATISFACTORY
- ↓ NEEDS IMPROVEMENT TRAINING
- T NEEDS COMPLETE TRAINING
- – NOT A JOB REQUIREMENT
- 7/6 DATE TRAINING BEGINS

	MACHINIST - 1st CLASS								2nd CLASS						
	E.T. Black	H.K. Harvey	T.E. Garrison	R.O. Bayne	E.M. Dolan	H.R. King	E.L. Ward	R.W. Smith	etc.	V.T. Rhodes	A. Henry	S.M. King	G.H. Jones	S.L. Lemmon	W.R. Mason	etc.
COMPANY SERVICE	24-3	15-5	26-1	19-3	32-4	30-1	33-9	12-4		26-3	12-1	18-2	19-1	22-3	12-6	
JOB SERVICE	12	8	15	5	21	24	18	4		20	4	12	11	15	2	
AGE	47	38	48	36	56	54	62	44		58	32	41	46	47	37	
JOB REQUIREMENTS																
1st CLASS: SINGLE STAGE CENTRIFUGAL PUMPS	✓	✓	✓		✓	✓	✓									
2-STAGE CENTRIFUGAL PUMPS	✓	✓			✓	✓	✓									
10-STAGE CENTRIFUGAL PUMPS	✓	✓			✓	✓	✓									
6-STAGE VERTICAL CENTR. PUMPS	✓				✓	✓	✓									
20-STAGE VERTICAL CENTR. PUMPS	✓															
ROTARY VACUUM PUMPS	✓	✓	✓		✓	✓	✓	✓								
KINNEY PUMPS (CAM TYPE)	✓	✓	✓			✓	✓	✓								
SINGLE STAGE AIR COMPR. VALVES			✓	✓	✓	✓	✓	✓								
DUPLEX AIR COMPR. VALVES	✓	✓	✓	✓	✓	✓		✓								
STEAM TURBINE	✓	✓	✓	✓	✓	✓	✓					✓				
VERTICAL STEAM ENGINE	✓			✓									✓			
ROTARY TYPE BLOWER	✓			✓	✓		✓	✓					✓			
ROTARY GEAR PUMP	✓	✓	✓	✓	✓		✓	✓				✓				
2nd CLASS: TEST & SET SAFETY VALVES										✓		✓	✓			
FORCE-FEED LUBRIC. FOR COMPR.										✓		✓	✓	✓		
HORIZ. SIMPLEX RECIPRO. PUMP												✓	✓	✓		
WEDGE GATE VALVE										✓	✓	✓				
GLOBE VALVE										✓	✓		✓		✓	
AIR MOTOR HOIST										✓		✓	✓	✓	✓	
LUBRICATED PLUG VALVE										✓		✓		✓		
SLIDE VALVE										✓		✓		✓	✓	
HORIZ. DUPLEX RECIPRO. PUMP													✓			

Fig. 1—Sample of the Job Training Schedule form used by Esso Standard Oil Co. in setting up actual training programs. This form shows job requirements at the left and lists employees at the top. Check marks indicate where employees meet the job requirements

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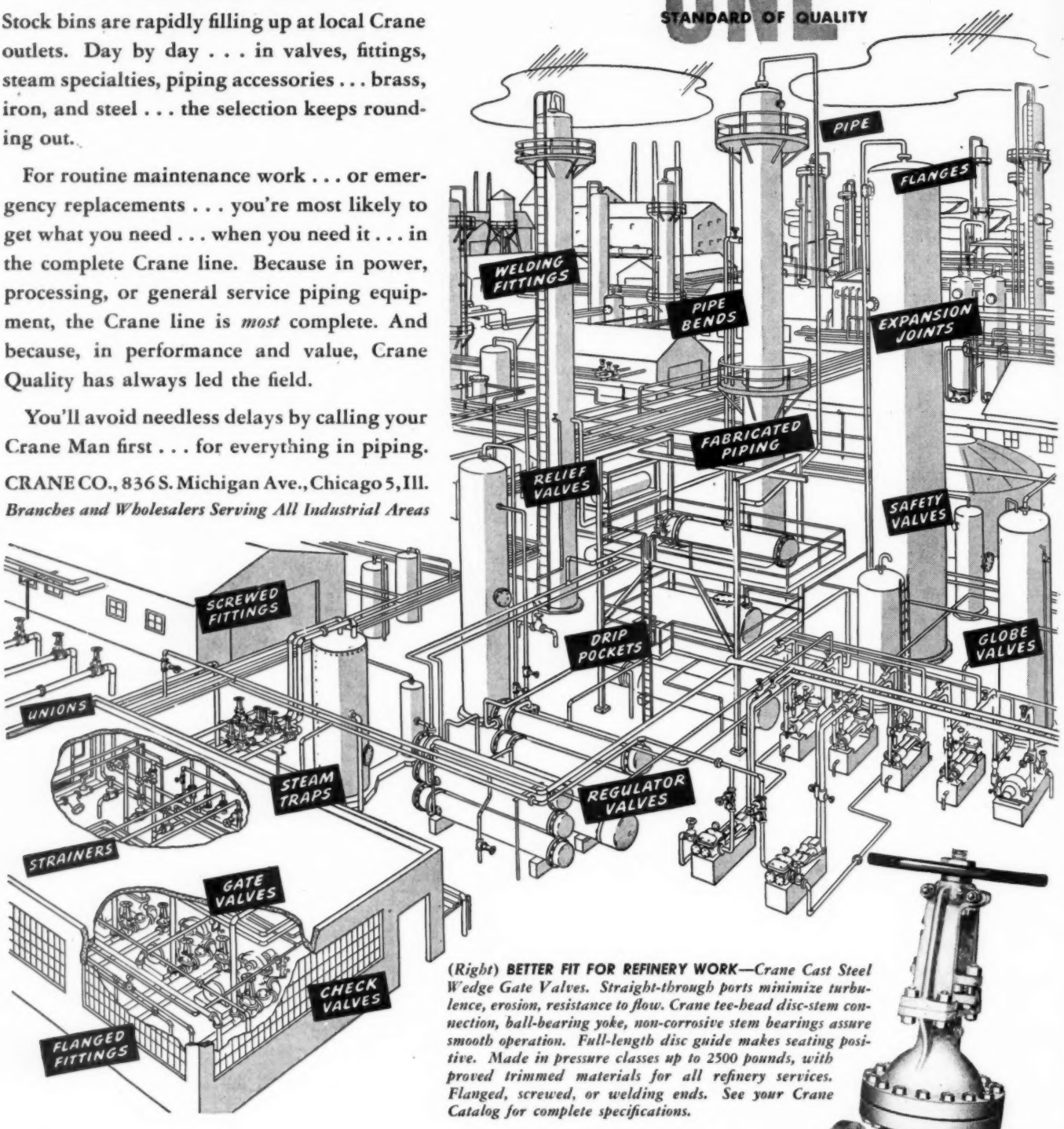

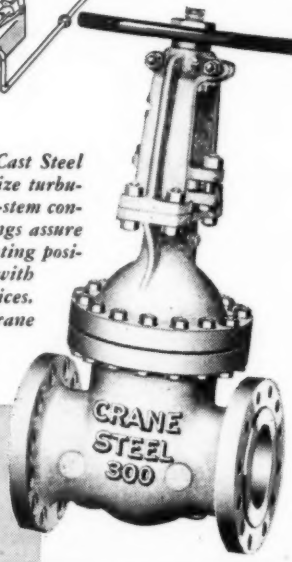

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High-Octane Fuels

Reviews of Papers Presented at the 13th Mid-Year Meeting of American Petroleum Institute Division of Refining, Philadelphia, May 10-13, 1948

Front-End Volatility as it Affects Processing of High-Octane Fuels

By L. L. DAVIS

Continental Oil Co., Ponca City, Okla.

The interrelationship of front-end volatility of motor gasoline and octane number requirement is shown for a series of increasing octane levels in assumed refinery operations. Processing for high-octane gasoline not only decreases the volume of base gasoline but produces more butanes than can be utilized in 10-lb. RVP gasoline, thus decreasing the amount of external blending stock the refiner requiries. Improvement in the ability of automotive engines to use high vapor pressure fuels would provide means for increasing production to more than offset the volume loss in base gasoline through advancing the octane number. Below are given the principal portions of the paper presented by Mr. Davis at the 13th Mid-Year meeting of the API Division of Refining, May 13.

REFINERY processing for the production of high-octane-number gasoline greatly increases the importance of using the maximum possible volatility for both maintenance of volume of production and increase in anti-knock value. Processing for higher octane numbers decreases the volume of gasoline heavier than butane, and, at the same time, increases the ratio of butane produced. The refiner, because of this increased production of refinery butanes, not only has a lesser volume of base gasoline, but also requires less external blending stocks such as natural gasoline and butane.

In order to show this interrelationship of front-end volatility and octane requirement, several operations have been calculated for an assumed prototype refinery at a series of increasing octane levels. The resultant gasoline productions at Reid vapor pressures of 8 psi, 10 psi, and 12 psi are shown plotted against octane number of the resultant total gasoline blend.

For the purpose of this discussion, the prototype refinery is assumed to be operating on an average crude oil of mixed base or "Mid Continent" type. The equipment and processing operations include:

a. Crude-oil distillation equipment capable of sharply fractionating the straight-run gasoline into: 1, a low-end-point high-octane fraction for blending into finished gasoline; and, 2, a 400°F.-end-point low-octane-number naphtha fraction to be reformed for the production of high-octane blending stock. The ratio of the two cuts can be varied as needed to meet a desired octane level.

b. Sufficient catalytic cracking equipment is assumed to be available to crack the virgin gas oil on a once-through basis at a conversion level of 50%. This represents about one-half the total cracking capacity required, and is approximately the catalytic cracking-capacity level of many refineries. For the highest octane levels, additional catalytic capacity must be added to permit total recycle of the charge stock.

c. The catalytic cycle stock is cracked to extinction in conventional thermal cracking equipment.

d. Heavy naphtha is reformed thermally, at a pressure of 750 psi, to a conversion level required to meet the desired octane value of the finished blend. The degree of reforming is the primary octane control. Yields and quality were calculated from the correlations in accepted practice.

e. All butylene and 75% of the available propylene are recovered and catalytically polymerized for high-octane blending stock.

f. The gasoline-blending bases are all debutanized to a vapor pressure of 8 psi.

g. All butane above 8-lb.-RVP gasoline is recovered and used for blending to the higher vapor-pressure levels.

h. In all cases the same amounts of middle distillates are produced; i.e., 15% straight-run distillates, and 10% No. 2 fuel oil which is half

THE AUTHOR

L. L. Davis, manager of manufacturing, Continental Oil Co., Ponca City, Okla., is a native of Kansas and received his M.S. in chemical engineering from the University of Washington in 1917. He has been with Continental since 1927 as technical assistant, superintendent of the Ponca City refinery and supervisor of the process division before assuming his present position.

straight-run and half cracked distillate.

With the assumed equipment, a refiner would have considerable flexibility in the operation and blending of the gasoline bases for the obtaining of the desired quality of gasoline. For the purpose of this discussion, it is assumed that, in order to produce the higher vapor-pressure gasolines, the refiner will first use all of the available butanes from the refinery operation and, second, will purchase 26-lb. natural gasoline.

The gasoline production is compared (in Fig. 1) with the anti-knock value of the gasoline, blended with 1.5 ml tetraethyl lead, expressed as the "research" octane number. The "par" production line represents the maximum possible volume of gasoline the refiner can make from the crude, using no external blending stocks. Under this par operation, the maximum 400°F. - end - point straight-run gasoline is used without reforming, and the cracking equipment is operated for maximum volume yield rather than high-octane yield. Under these conditions the total production, including all butane, blends to approximately 10-lb.-RVP, and has an octane value of 78.3.

The approximately vertical line *A-A'* represents the same par operation, in which more or less butane or natural gasoline is used to meet seasonal vapor-pressure requirements. If, as in the summer, the total production is debutanized to 8-lb.-RVP gasoline, the loss in yield would be 3% and the octane number would drop to 77.4.

In the winter, inasmuch as all the refinery butane had been blended to make 10-lb.-RVP gasoline, it would be necessary to use external natural gasoline and butane to reach the permissible limit of 12-lb.-RVP. The Bureau of Mines data show that the average available natural gasoline is about 6.3% of the volume of refinery gasoline. As this volume is insufficient to make the desired 12-lb.-RVP gasoline, 1.3% external butane is also used—making the total 12-lb.-RVP gasoline production 7.8% above par, with an octane value of 79.5.

Thus, with this maximum production operation, the yield difference between 8- and 12-lb.-RVP gasoline is 10.8%, with an octane number range of from 77.4 to 79.5.

In order to improve the anti-knock value of the gasoline beyond the par value, the most economic procedure—and that usually elected—is to reform the heavier low-octane naphtha. Fig. 1 shows the effect of such reforming, with increased severity as the octane number increases.

As an example, if about 4 octane-number improvement is desired, as shown in operation line *B-B'*, the 8-lb.-RVP gasoline line at 81.5 octane shows a yield of 6% below par. The 10-lb.-RVP gasoline shows a yield loss of 3% at an octane level of 82.3. Because of the increase in thermal cracking, there is now more refinery butane available than is required for 10-lb.-RVP gasoline, as is shown by the refinery butane line (the dotted line marked *R*). All of the refinery surplus butane and the natural gasoline (dotted line marked *N*) can still be blended to make 12-lb.-RVP gasoline with a yield of 4.5% above par at 83.4 octane number.

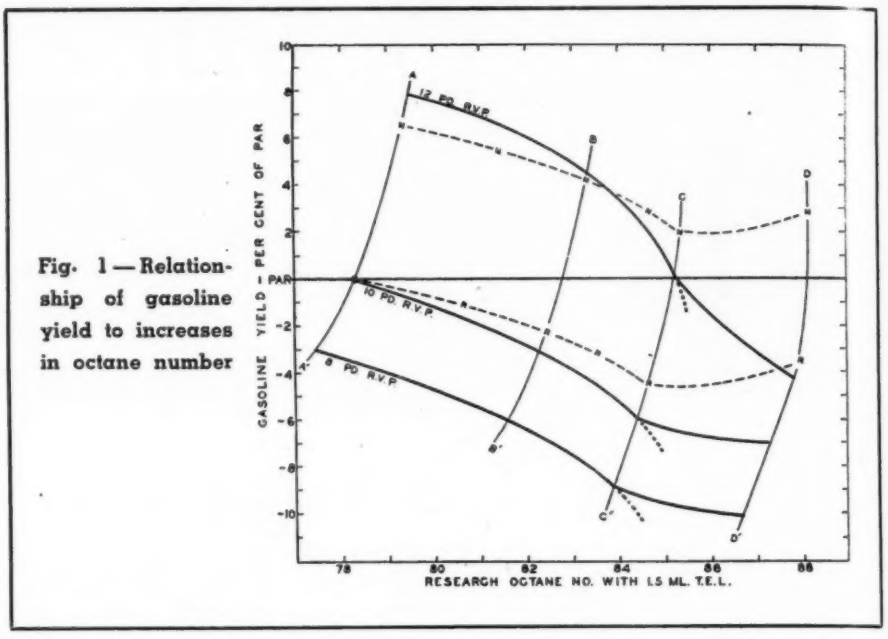

Fig. 1 — Relationship of gasoline yield to increases in octane number

If the reforming is continued to the point of diminishing return, octane numbers on the order of 84 to 85 may be obtained, as shown by operation line *C-C'*. Under this condition the 8-lb.-RVP gasoline shows a yield of 9% less than par at 84 octane number, and the 10-lb.-RVP gasoline 6%, less than par at 84.4 octane number. Under this severity of cracking, however, there is so much surplus butane that all the available natural gasoline could not be used in a 12-lb. product. Therefore, the yield drops to 0.1% above par at 85.2 octane number, and 1.8% of natural gasoline would have to find another market.

Catalytic Cracking for High Octane

Beyond this, anti-knock value can be improved only by adding other processes, such as complete catalytic cracking. The final operation, line *D-D'*, on the chart assumes discontinuation of thermal cracking by doubling the catalytic cracking investment but continuing heavy reforming. Under these conditions, the 8-lb.-RVP-gasoline yield drops to 10% below par at 86.7 octane number and the 10-lb. to 7% below par at 87.2 octane number.

Because of the large production of butanes by catalytic cracking, there would now be more butane available than is needed for 12-lb.-RVP gasoline. As a result, the 12-lb. yield drops to 4.3% below par at 87.8 octane number, and all the natural gasoline and 0.6% butane become surplus.

The overall loss in gasoline yield is of considerable magnitude, particularly under the current conditions of production shortages. As an example as compared to a car which could operate in the summer with a 12-lb.-RVP gasoline of 79.5 octane number to one which requires 8-lb.-RVP gasoline of 86.5 octane number, the production loss would be 18%. The 12-lb.-RVP gasoline shows a loss in yield of 12.1% for a gain in octane of 8.3 numbers, whereas the 10- and 8-lb.-RVP gasolines show yield losses of 7% for an octane gain of 9 numbers.

This loss in gasoline yield is an economic waste, as it represents a permanent loss of liquid hydrocarbons. With the exception of a small amount of heavy fuel, the loss results in the production of fuel gas which may be used by the refiner in place of natural gas or coal.

In the foregoing discussion, the anti-knock values are for the total refinery blend. If the desired volume and octane value of premium and housebrand gasolines were known, the average might be calculated. Thus, if 30% of premium at 93 and 70% of housebrand at 80 research octane number are needed, the refinery average would be 84 octane number; and, from the chart, the yields would be —9% at 8-lb.-RVP; —5.3% at 10-lb.-RVP; and +3.4% at 12-lb.-RVP gasoline.

It is important to note that the gain in motor octane number for the same loss in yield is much less than for research octane. This difference in gain between the motor and research octane numbers results from the fact

that all of the processes used for high-octane production give an increase in the spread between the two methods, thus increasing the research octane numbers at a more rapid rate than the motor octane numbers.

Other Examples

Many other cases might be considered, but they would add little to the general trend shown by this example. In practice, a given refiner must consider many other variables. Thus, if he has pressure tankage, he may store natural gasoline for winter use, thereby improving his winter-grade yields. A refiner remote from natural-gasoline supplies may be forced to store butane for winter blending, and thus he will lose all the volume gain available from natural gasoline.

As the anti-knock requirements advance beyond the levels indicated, or as equipment becomes available and economies permit, the refiner may materially improve the volume-to-octane relation by installing more highly specialized processes. These may include: *a*, hydro-formation, or cyclization and isomerization in place of the naphtha reforming; *b*, alkylation instead of polymerization both to increase rich blending stock and decrease surplus butane; *c*, butane isomerization, and possible dehydrogenation, for increased alkylate production, and *d*, hydrogenation, either destructive or for the improvement of *iso*olefins.

Conclusions

Increase in the octane-number requirement of automotive engines greatly enhances the need for improvement in the tolerance of the engine to highly volatile fuels. Processing for high-octane fuels reduces the volume of base refinery gasoline approximately 1% for each octane-number improvement. At the same time the amount of surplus refinery butane is increased rapidly with increase in octane number. The amount of natural gasoline and butane the refiner may use in the current low-vapor-pressure fuels approaches the vanishing point, with further reduction in available motor gasoline. Improvement in the ability of an engine to use high-vapor-pressure fuels both increases the volume and octane number, and decreases the loss in volume of base gasoline for the same blended octane number. An increase in summer vapor-pressure tolerance from 8 lb. to 12 lb. would increase production by 10 to 11%, thus more than offsetting the volume loss which will occur with octane-number increase of 10 points.

Tail-End Volatility of Gasoline

By J. BENNETT HILL and WALTER C. HUFFMAN
Sun Oil Co., Marcus Hook, Penna.

A REVIEW of a paper under the same title presented before the 13th Mid-Year Meeting of the API Refining Division, Philadelphia, May 13, 1948.

DURING the 10 years preceding the war there was a marked downward trend in the tail-end boiling points of motor gasoline. This trend was influenced to some extent by an alleged competitive advantage of better volatility in the last half of the distillation range. The primary reason, however, was the desire of refiners to obtain higher octane numbers.

Keeping up with the octane race necessitated undercutting the gasoline components both from the straight-run towers and from the cracking plants. The octane advantage of this practice is evident from Fig. 1,* which shows the octane numbers of individual successive fractions of typical straight-run and thermally cracked products plotted against their 50% points. Where it was necessary to squeeze out the last octane number, it was obviously desirable for refiners to drop out the higher-boiling, low-octane fractions from both of these sources.

This downward trend in tail-end boiling points of motor gasoline has been taken advantage of by the automotive industry in the design of their intake systems. The better tail-end volatility permitted them to design for a cooler intake and to obtain the consequent advantage of better volumetric efficiency.

The extensive application of catalytic cracking during the war to produce aviation gasoline caused a basic change in this picture. During the war catalytic cracking plants were erected to the extent of about 880,000 b/d charging capacity and it is estimated that, by the end of 1948, catalytic cracking capacity will total 1,200,000 b/d. Catalytically cracked gasoline from these units will comprise about 22% of the total gasoline production of the country.

Catalytic gasoline differs from straight-run or thermally cracked gasoline in that there is substantially no decrease in octane number in the higher-boiling fractions. There is no octane advantage in undercutting catalytic gasoline and a refiner will certainly wish to take the maximum possible yield from his catalytic units. This is limited practically only by the point where the light, uncracked ends of the charge begin to contaminate the product and lower the octane number. It is even practical and economic to accept a slight amount of this contamination.

Fig. 2, which is a composite curve from many sources, is based on a charge which does not overlay the product. It shows the variation of the Research and Motor octane numbers of the catalytic gasoline as the 90% point is increased, as well as the effect of such increase on the yield from the unit, based on 100 for a 90% point of 360° F.

It will be noted that both octane curves are substantially horizontal-indicating that, on the average, the sensitivity of the catalytically cracked fuel is the same in the upper boiling ranges as in the lower. Also there is no significant change in the lead susceptibilities.

Inasmuch as larger yields of gasoline on the catalytic units mean more barrels of gasoline from a given amount of crude, there is economic pressure on the refiner to incorpo-

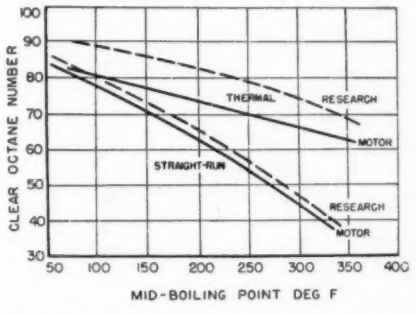

Fig. 1—Variation of octane numbers of fractions with 50% distillation point

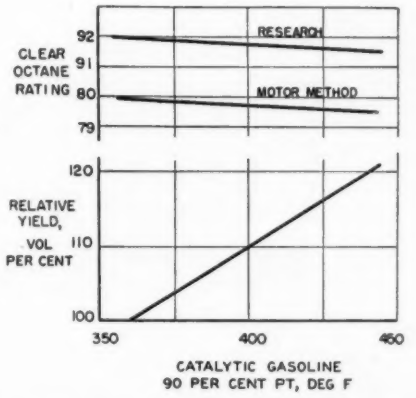

Fig. 2—Effect of 90 % point of catalytic gasoline cut on octane number and yield

* Arrangement of charts and tables does not coincide with that in the original paper.

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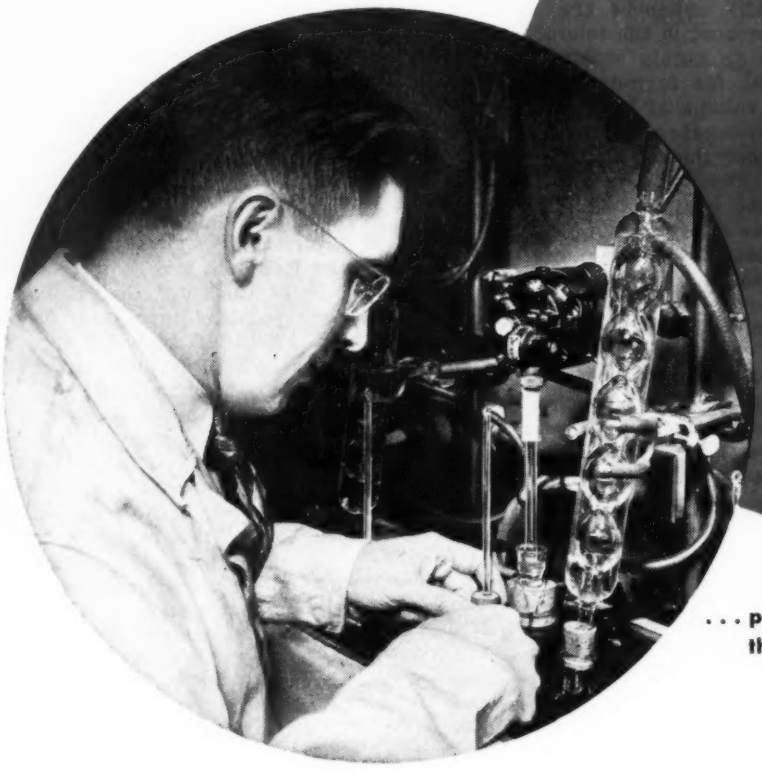

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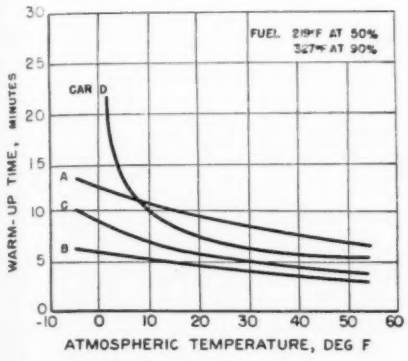

Fig. 3.—Effect of atmospheric temperature on warm-up time for four cars with the same gasoline

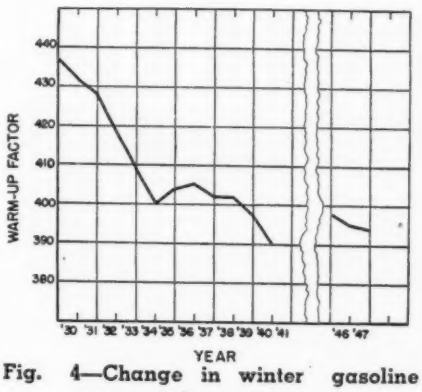

Fig. 4—Change in winter gasoline warm-up factor, by years

rate these heavier catalytic fractions into his gasoline. The net result of this practice would be to raise the tail-end boiling points of the gasoline delivered to the customer.

Tests on the immediate prewar and postwar automobiles have shown that in cold weather they will not function properly on much higher boiling points than those of current gasoline. The present range of boiling points is apparently not critical in warm weather, but in winter the effect of the higher boiling points is to lengthen the warm-up period of the car after a cold start.

One authority[1] has defined this warm-up period as the time of operation before satisfactory acceleration can be obtained with no use of the choke. Fig. 3, reproduced from his data, shows the difference in warm-up time of 4 cars in good condition on the same fuel, a comparatively volatile one. The differences are considerable and, in fact, one car failed to warm up at all at an atmospheric temperature of 0° F.

It was shown that the warm-up time in a group of cars correlates with the tail-end volatility and, specifically, with the "average 65% point", which is the average of the 40-, 50-, 60-, 70-, 80- and 90% evaporated points on the ASTM distillation.

Further experience indicates that a simpler index, which correlates practically as well, is the sum of the 50% plus half of the 90% evaporated points, which index is used as the "warm-up factor". The average warm-up factors for winter gasoline, calculated from changes in gasoline tail-end boiling points, are shown in Fig. 4. These figures are averages covering the warmer parts of the country as well as the colder parts. The averages for northern states, requiring winter grades of gasoline, will be materially lower. It is estimated that this northern winter average for the past winter was 388. While there is available no critical value for this index for satisfactory operation, it is certain that, for temperatures below 30° F., a gasoline with a warm-up factor say of 430 will give appreciably less satisfactory performance in current cars than one with an index of 390.

To appreciate quantitatively the problem which this condition poses for the refiner, it is necessary to examine the economics of cutting the catalytic gasoline stream deeper, as well as its effect on the warm-up factor of the finished gasoline. The problem is particularly acute in those refineries which have a high concentration of catalytic capacity and is of less importance in those plants where the percentage of catalytic cracking capacity is low.

Holaday[2] has projected as one of a series of refineries, a balanced refinery in which catalytic cracking is used particularly advantageously. This projected refinery includes crude distillation, thermal reforming and thermal cracking, catalytic cracking, vapor recovery, catalytic polymerization and alkylation. Fig. 5 shows the flow sheet of this refinery, which produces a total of 54,600 bbl.[3] of finished 9-lb. RVP gasoline from 100,000 bbl. of crude charged. Of this total gasoline, 40% is debutanized catalytic gasoline, cut to a 90% point of 380° F.

This refinery was recalculated for lighter and heavier catalytic gasoline cuts; namely, with 90% points of 360 and 430° F. respectively. In this calculation the following assumptions were made:

1—To prevent overlap between the catalytic charge and the product in the case of the 430° F. product, a certain amount of the front end of the charge must be diverted to thermal cracking.

2—The increase or decrease of the catalytic gasoline stream is at the expense of, or the advantage of, the catalytic stream to distillate fuel oil.

3—The octane number of the fin-

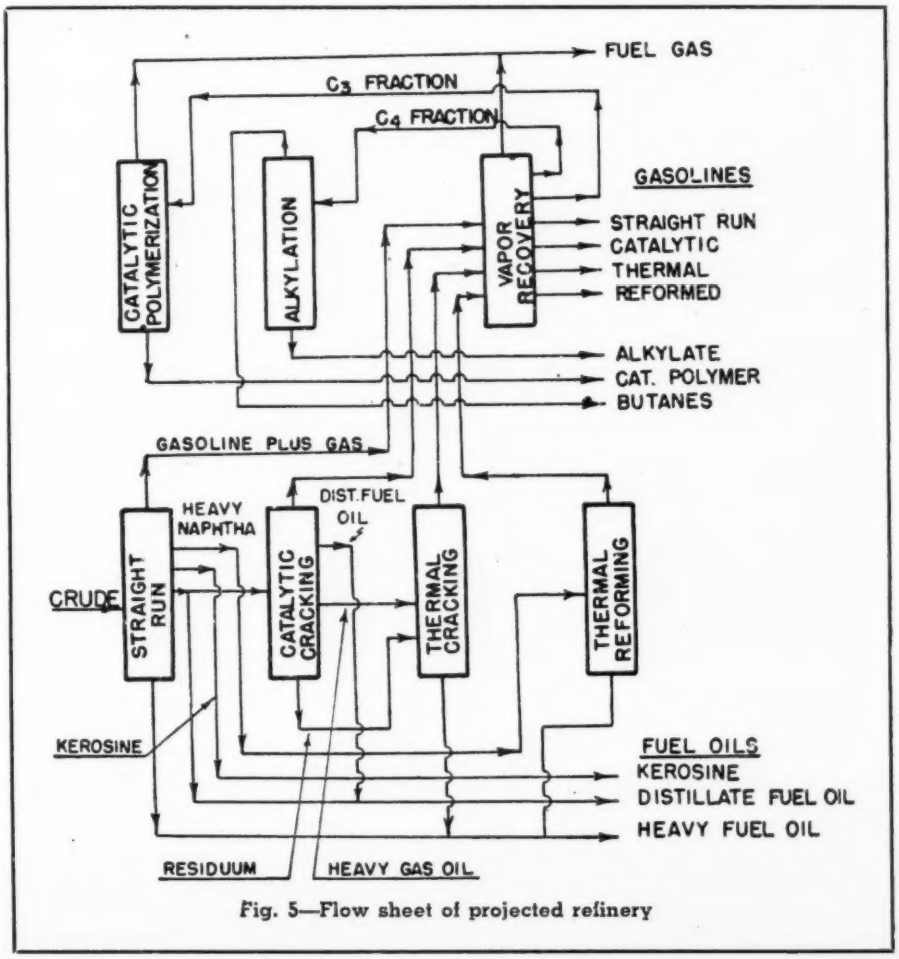

Fig. 5—Flow sheet of projected refinery

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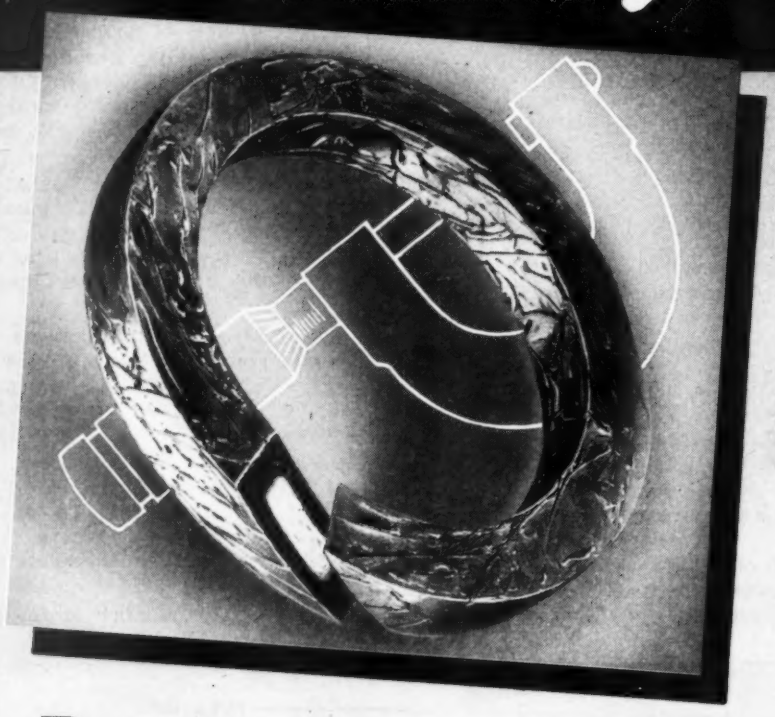

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TABLE 1—Recalculation of Yields from Projected Refinery

	I	II	III
90-per-cent point of catalytic gasoline, deg. F...	360	380	430
Catalytic gasoline, barrels	20,700	21,800	24,400
Finished gasoline, barrels	53,800	54,600	56,400
Gain in barrels of gasoline		800	2,600

ished gasoline is kept constant by altering the quantity of straight-run gasoline recovered and blended.

The recalculation of these two cases, together with Holaday's original case, results in the production figures for 100,000 bbls. of crude charged as given in Table 1. The discussion of these production changes in the paper is as follows:

"It is seen that the total change from cutting the catalytic gasoline stream from 90% at 360° F. to 90% at 430° F. results in 2,600 bbls. more gasoline, or an increase of 2.6% in the gasoline output of this refinery. If this volume increase is based back on the volume of catalytic gasoline, the per cent increase is substantially independent of the concentration of catalytic cracking capacity in the refinery and may, therefore, be applied to the country as a whole.

"Let us assume that the total catalytic charging capacity of the country is 1,200,000 b/d, and that average practice gives a catalytic gasoline yield of 42% of product with a 90% point of 370° F. This would mean 504,000 b/d of catalytic gasoline of this quality. Compared with this, the yield of catalytic gasoline with a 90% point of 430° F. would be about 577,000 b/d and, taking all things into consideration and keeping octane number constant, the total gasoline production of the country from the same crude would be increased by 50,000 b/d. With a 43% average yield of gasoline from crude, this corresponds to a saving of 115,000 b/d of crude.

"Although a catalytic gasoline of higher octane will be obtained if the true initial boiling point of the charge is higher than the gasoline end point, it would appear permissible to increase the boiling range of the gasoline product beyond the limit which would be dictated by completely avoiding product contamination from

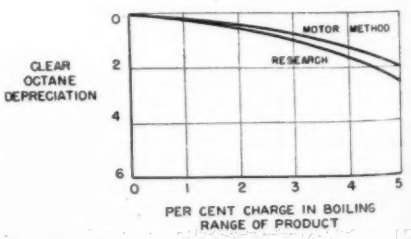

Fig. 6—Effect of contamination of product with charge

THE AUTHORS

Dr. Hill

J. Bennett Hill, director of the Chemical and Engineering Division, Research and Development Department, Sun Oil Co., graduated from the University of Pennsylvania with a B. S. in chemistry in 1913, Ph. D. in 1916, and received a degree in chemical engineering in 1937. He worked for Barrett Co. and was chief chemist for Atlantic Refining Co. from 1924 to 1934, leaving to go with Sun Oil Co.

Mr. Huffman

Walter C. Huffman, chief of the technical service section of the development laboratories of Sun Oil Co., graduated from Purdue University in 1935 with a B. S. in chemical engineering. He was in process work at the Aruba refinery of Lago Oil and Transport Co. until 1942, when he was employed as a development engineer by Sun.

TABLE 2—Properties of Finished Gasoline in Three Cases of Projected Yields

	I	II	III
90-per-cent point of catalytic gasoline, deg F	360	380	430
Finished gasoline:			
Research octane number plus 1 ml TEL per gallon	92	92	92
Motor octane number plus 1 ml TEL per gallon	84	84	84
Reid vapor pressure, lb	9.0	9.0	9.0
50-per-cent point	231	235	240
90-per-cent point	348	350	382
Warm-up factor	405	410	431

uncracked charge. Fig. 6 indicates the effect of overlap between product and charge-stock boiling ranges, and shows the deleterious effect of the increasing quantity of uncracked fractions on octane number and sensitivity.

"However, considering that the distillation curve of the front end of the charging stock is typically much steeper than the distillation curve of the product gasoline, it may be possible to increase yield appreciably with little loss in octane number, because an increase of 10° F. in gasoline 90% point will raise the yield approximately 1% on charge, and may include a negligible percentage of uncracked light ends from the charge. Although the exact cut point of the catalytic gasoline which a given refiner can profitably recover will depend on his own situation, an increased yield of gasoline with small loss in octane rating would appear feasible."

Whichever way the refiner chooses to take advantage of the high octane numbers of heavy catalytic fractions, the effect of raising the boiling points of the final gasoline is the same. This may be seen quantitatively by going back to the three cases shown in Table 1, in which the properties of the finished gasolines would be as shown in Table 2.

By repressuring to 12-lb. RVP, the warm-up factor would be decreased approximately 8 points. Even with this allowance, the warm-up factors in cases II and III are above the range of current gasolines and probably within the range that the car and its driver would not like in cold weather.

There seems to be little the petroleum industry can do in the matter other than to take the sacrifice in gasoline production which is necessary to satisfy the requirements of present cars. The potential gain in gasoline output must be balanced against the possible economic losses which might accrue if cars were designed for this heavier type of fuel, and possibly a compromise would have to be reached.

"With a realization, however, of how much fuel potential to their cars is being lost through meeting present tail-end volatility requirements, the automotive industry should have a powerful stimulus to see what can be done about it," the paper concludes.

"In the meantime, tail-end boiling points are certain to rise somewhat and the motorist will have to take his choice between blaming the oil company or the car manufacturer for the poorer cold-weather performance he may encounter."

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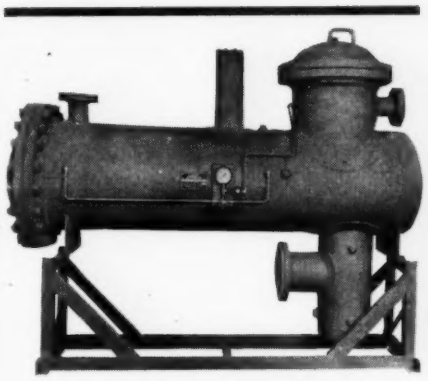
(1) J. G. Moxey, Jr., "Engine Warm-up with Present-Day Fuels and Engines", Quart. Trans. Soc. Automotive Engrs. 1 (3) 441 (1947).

(2) W. M. Holaday, "The Efficient Production and Utilization of Motor Gasoline," Soc. Automotive Engrs. Preprint No. 120, Jan. (1948).

(3) Figures on this refinery not included in Holaday's paper are from a private communication or calculated therefrom.



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Crude Oil, Natural Gasoline and Liquefied Petroleum Products

Butane Utilization

Reviews of Papers Presented at the 13th Mid-Year Meeting of American Petroleum Institute Division of Refining, Philadelphia, May 10-13, 1948

Problems in the Efficient Utilization Of Refinery Butanes in Motor Gasoline

By T. L. APJOHN and D. P. HEATH, Research and Development Dept.
Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

With current interest in the conservation of petroleum in mind, an analysis of overall potential energy recovery is made of the alternate use of excess butane-butylene fractions as feed stock for conversion to liquid fuel products and as a direct blending stock in motor gasoline.

On the basis of available data, higher energy recoveries could be made by chemically converting excess butanes to gasoline than by direct blending into gasoline. This conclusion results largely from high evaporation losses encountered from automobile tanks and carburetors, which losses could undoubtedly be reduced markedly by revisions in fuel-system design.

A REVIEW of a paper under the same title presented before the 13th Mid-Year Meeting of the API Refining Division, Philadelphia, May 13, 1948.

THIS presentation is concerned with the problems that arise in the utilization of refinery butane-butylene fractions, either through conversion to liquid fuel products or through direct blending into motor gasoline.

With the current interest in conservation of petroleum resources in mind, the analysis is directed toward an evaluation of the most efficient utilization of these materials from the standpoint of overall *potential energy recovery*, rather than on the basis of economic return to the refining industry.

In the conversion of butane-butylene fractions into gasoline, three well-known types of processes can be used; alkylation, catalytic polymerization and thermal polymerization. To establish the merits of these processes as conservation procedures, for comparison with the direct utilization of butanes in motor fuels, the following two sets of assumptions were made:

First, the amount of butylenes and isobutane present in a refinery butane-butylene fraction has been assumed to be large enough to permit alkylation or catalytic polymerization of all of this fraction not required to meet normal vapor pressure requirements. Second, typical fuel and utility requirements and yields have been assumed for operations of these processes in which the charge stock does not contain appreciable amounts of propane-propylene or pentane-pentene. On the

THE AUTHORS

Mr. Apjohn

T. L. Apjohn, supervisor, research and development department, Socony-Vacuum Oil Co., Inc., Paulsboro, N. J., graduated from Massachusetts Institute of Technology in 1934 with a B. S. in chemical engineering. He entered the technical service laboratories of Socony-Vacuum in 1936 and in 1940 was transferred to the general laboratories.

He was an aviation officer during the war and returned to Socony in 1945 as assistant to the director of its laboratories. Since October, 1946, he has been supervisor of the light products division in the research and development department.

Mr. Heath

Donald P. Heath, senior engineer in the research and development department of Socony-Vacuum, graduated from Purdue University with a B. S. in chemical engineering. From 1940-45 he was in the technical service laboratory, working on evaporation loss projects and utilization of aviation gasolines. At present he is group leader on utilization and performance characteristics of motor and aviation fuels.

TABLE 1—Energy Balances for the Refinery Butane Conversion Processes

	Alkylation	Catalytic Polymerization	Thermal Polymerization
C_4 hydrocarbons reacting	*Iso*butane Butylenes	Butylenes	*Iso*butane *n*Butane Butylenes
Energy required to operate process, Btu per gallon of gasoline produced:			
Reactants	123,000	125,000	235,000
Fuel and utilities	21,000	11,000	.....
Total	144,000	136,000	235,000
Energy content of products, Btu per gallon of gasoline produced:			
Gasoline	112,000	112,000	112,000
Fuel	.....	.....	73,000
Total	112,000	112,000	185,000

basis of these latter assumptions, the energy balances for the butane conversion processes were determined as shown in Table 1.(1)

As indicated in the tabulation, the energy required to operate a thermal polymerization plant is available in the gas stream produced in this process. Therefore, no energy is required in the process other than that contained in the hydrocarbons reacting. In alkylation and catalytic polymerization, however, energy is required in addition to that contained in the hydrocarbons reacting.

"The efficiency of these conversion processes on an energy basis is equal to the energy content of the products divided by the total energy required to operate the process," the paper states. "In this respect thermal polymerization is difficult to compare with the other processes, because a portion of its product is fuel gas which is of a lower value than gasoline.

"The energy efficiencies are approximately 78, 82 and 79 for alkylation, catalytic polymerization and thermal polymerization, respectively. The corresponding energy losses are about 22, 18 and 21%."

These latter figures are used in the comparison of the conversion processes as methods of utilizing excess butane-butylene fractions with the direct inclusion of these materials in motor gasoline.

Direct Use of Excess Butane

Motor fuel vapor pressures are increased by inclusion of butanes approximately 2 lb. for each 3% of butane. Actual increases depend upon the physical characteristics of the base gasoline and the composition of the butane-butylene fraction used. Most refineries would be able to produce a gasoline, using total available butanes, with an average between 14-15 lb. Rvp. This level is well above that allowed by most specifications for winter-grade fuel and almost double that for summer grade.

The advantages are recognized of adding butanes to gasoline in increasing anti-knock rating and improving warm-up characteristics of the motor fuel.

One of the major difficulties arising from increased butane utilization in gasoline is vapor lock in automobile engines. Most recent test data indicates that some increases in fuel vapor pressure can be tolerated, particularly in winter. On the whole, however, the allowable increases are small compared to those that could be obtained by using all butane fractions in this manner.

Another disadvantage of greater butane utilization which is highly important from the conservation standpoint is evaporation loss. This factor has been closely followed by the petroleum industry in handling gasoline as the product moves from the refinery, through terminal and bulk storage, to the service station.

Losses between the service station tank and the cylinders of automotive engines have not been so carefully checked and there has not been a recognition of these losses on the part of the automobile operator.

The extent of loss by evaporation in the handling and storing of gasolines was intensively investigated. As an example of losses in moving gasolines of increased vapor pressure from a refinery to a service station, a series of handling operations was assumed which is typical of that encountered by a number of companies marketing gasolines on the East Coast. These include:

1—Manufacture and terminal storage in the Gulf.

2—Shipment by tanker to an East Coast port.

3—Storage at terminal.

4—Shipment by barge to bulk plant.

5—Storage at the bulk plant.

6—Delivery by tank truck to service station.

7—Storage at the service station in an underground tank.

TABLE 2—Sequence of Gasoline Storage and Handling Operations

Operation	Rate of Loss	Fuel Temperature, °F: Summer	Intermediate	Winter
1. Storage in Gulf Coast Shore Tank—Floating Roof Tank, 120 ft. Diameter, 5,000,000 bbls/yr throughput	Loss (gals/yr) = 22.5 x Tank Diam. (ft.) x Vap. press*	85	75	55
2. Filling Tanker	$\% = \frac{\text{Vap. press*}}{3.75\ (14.7\text{-Vap. press*})}$	85	75	55
3. Storage in Tanker during Trip	Nil	..	..	..
4. Filling East Coast Storage Tank—Floating Roof	Nil	..	..	..
5. Storage in East Coast Tank—Floating Roof 120 ft. diameter, 1,250,000 bbls/yr throughput	Loss (gals/yr) = 22.5 x Tank Diam. (ft.) x Vap. press*	75	50	30
6. Filling Barge	$\% = \frac{\text{Vap. press*}}{3.75\ (14.7\text{-Vap. Press*})}$	75	50	30
7. Storage in Barge	Nil	..	..	..
8. Filling Cone Roof tank in bulk plant	$\% = \frac{\text{Vap. press*}}{2.25\ (14.7\text{-Vap. press*})}$	70	55	25
9. Storage in Cone Roof Tank at Bulk Plant—50 ft. Diameter, 120,000 bbls/yr throughput	Loss (gals/yr) = 1.0 x Tank Area (sq.ft.) x Vap. press*	70	55	25
10. Filling Tank Truck	$\% = \frac{\text{Vap. press*}}{3.75\ (14.7\text{-Vap. press*})}$	70	55	25
11. Storage in Tank Truck	Nil	..	..	..
12. Filling Underground tank at Service Station	$\% = \frac{\text{Vap. press*}}{2.25\ (14.7\text{-Vap. press*})}$	70	55	25
13. Storage in Underground Tank at Service Station	Nil	..	..	..
14. Filling Passenger Car Tank	$\% = \frac{\text{Vap. press*}}{2.25\ (14.7\text{-Vap. press*})}$	70	55	25
15. Storage in Passenger Car Tank, throughput 15 gallons/week	From Correlation of Paulsboro Road Tests given on Figure 3	70	55	25
16. Evaporation in Carburetor bowl	% = ½ [R.V.P. (lbs) + 0.096t (°F)-17.43]	104	89	59

* The term vap. press. used in these expressions is the true vapor pressure of the gasoline at the storage temperature in lbs. per square inch.

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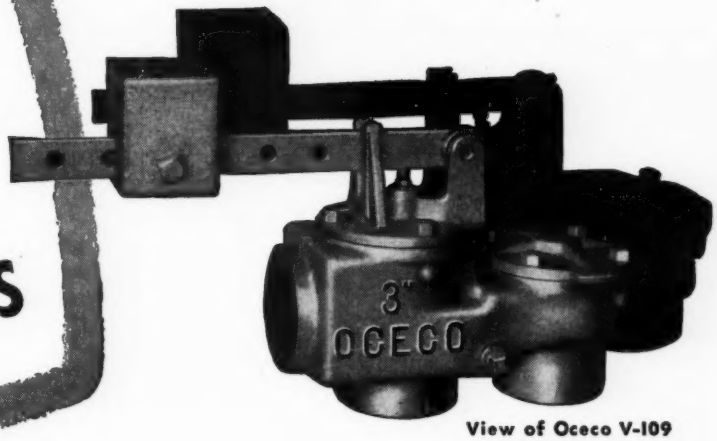

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TABLE 3—Evaporation Losses in Gasoline Storage and Handling Operations

Operation	SUMMER 8.0 lb. R.V.P. Vol. %	SUMMER 10.0 lb. R.V.P. Vol. %	SUMMER 12.0 lb. R.V.P. Vol. %	SUMMER 14.0 lb. R.V.P. Vol. %	SUMMER 16.0 lb. R.V.P. Vol. %	INTERMEDIATE 8.0 lb. R.V.P. Vol.%	INTERMEDIATE 10.0 lb. R.V.P. Vol. %	INTERMEDIATE 12.0 lb. R.V.P. Vol. %	INTERMEDIATE 14.0 lb. R.V.P. Vol. %	INTERMEDIATE 16.0 lb. R.V.P. Vol. %	WINTER 8.0 lb. R.V.P. Vol. %	WINTER 10.0 lb. R.V.P. Vol. %	WINTER 12.0 lb. R.V.P. Vol. %	WINTER 14.0 lb. R.V.P. Vol. %	WINTER 16.0 lb. R.V.P. Vol.%
1.	0.008	0.011	0.012	0.015	0.016	0.007	0.009	0.011	0.012	0.014	0.005	0.006	0.007	0.008	0.009
2.	0.212	0.339	0.528	0.888	1.896	0.156	0.234	0.339	0.471	0.732	0.089	0.127	0.166	0.225	0.259
3.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
4.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
5.	0.028	0.035	0.042	0.048	0.055	0.017	0.022	0.026	0.029	0.034	0.011	0.014	0.017	0.019	0.022
6.	0.156	0.234	0.339	0.469	0.732	0.079	0.110	0.144	0.169	0.214	0.046	0.063	0.080	0.090	0.108
7.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8.	0.223	0.331	0.463	0.614	0.865	0.148	0.212	0.276	0.336	0.430	0.068	0.092	0.117	0.128	0.153
9.	0.192	0.245	0.292	0.332	0.378	0.144	0.183	0.219	0.245	0.280	0.076	0.098	0.118	0.129	0.147
10.	0.134	0.199	0.278	0.368	0.519	0.089	0.127	0.166	0.202	0.258	0.041	0.055	0.070	0.077	0.092
11.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12.	0.223	0.331	0.463	0.614	0.865	0.148	0.212	0.276	0.336	0.430	0.068	0.092	0.117	0.128	0.153
13.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Total, Refinery to Service Station	1.176	1.725	2.417	3.348	5.326	0.788	1.109	1.457	1.800	2.392	0.404	0.547	0.692	0.804	0.943
14.	0.223	0.331	0.463	0.614	0.865	0.148	0.212	0.276	0.336	0.430	0.068	0.092	0.117	0.128	0.153
15.	0.385	0.680	1.010	1.38 est.	1.7 est.	0.195	0.360	0.535	0.680	0.915	0.055	0.085	0.125	0.155	0.205
16.	0.253	1.253	2.253	3.253	4.253	negligible	0.533	1.533	2.533	3.533	negligible	negligible	0.093	1.093	2.093
Total, Service Station to Use...	0.861	2.264	3.726	5.247	6.818	0.343	1.105	2.344	3.549	4.878	0.123	0.177	0.335	1.376	2.457
Overall Total	2.037	3.989	6.143	8.595	12.144	1.131	2.214	3.801	5.349	7.271	0.527	0.724	1.027	2.180	3.394

Details for the prediction of rates of loss, which are those recommended by Happel and Heath[2], as well as assumed storage temperatures for the summer, winter and intermediate seasons are summarized in Table 2.

Terminal storage tanks are assumed to be of the floating-roof type and to have a nominal capacity of 100,000 bbls. Throughput is calculated to be 5,000,000 bbl. per year at the Gulf terminal and 1,250,000 bbl. at the East Coast terminal. In this type of storage the evaporation loss is a function of the period of storage, diameter of tank, and the *true* vapor pressure of the fuel as expressed by the formula:

Evaporation loss (in gallons per year) = 22.5 × Tank diam. (in ft.) × vapor pressure (in lbs.).

Filling losses into bulk plant and service station tanks are a function of the true vapor pressure of the gasoline as expressed by the formula: Per cent by volume of loss = Vapor pressure (in lbs.)/[2.25] [14.7 − vapor pressure (in lbs.)].

Filling losses into tankers, barges and tank trucks are less than those into bulk plant and service station tanks because, during the rapid filling and draining cycles used, incomplete saturation of the air in the tank is effected. These losses are also dependent on the true vapor pressure of the gasoline, and may be approximated by the following formula:

Per cent by volume of loss = Vapor pressure (in lbs.)/[3.75] [14.7 − vapor pressure (in lbs.)].

Storage losses in the tanker, barge, tank truck and the underground storage tank at the service station are considered to be insignificant, as is the loss in transferring to the floating-roof terminal tanks.

The various losses that would be encountered in this handling sequence at the average temperatures experienced during summer, winter and the intermediate seasons and at various Reid vapor-pressure levels are given in Table 3. The total losses from refinery into service station tanks are plotted in Fig. 1 as a function of Reid vapor pressure. Values for selected conditions are given in Table 4, together with the percent by volume of loss of the butane added to obtain given increases in vapor pressure.

Thus, as far as handling to the service station tank is concerned, losses from evaporation in the summer are about the same as those experienced in refinery conversion processes. In the intermediate and winter seasons, however, the evaporation losses are smaller than the conversion losses. The case for direct butane utilization in gasoline is strong in the intermediate and winter seasons.

The extent of evaporation loss from the time gasoline is metered through the service station pump into a car until the fuel is burned in the combustion chamber of the engine was studied to permit a preliminary evaluation of the extent to which these losses would be increased by the use of higher vapor pressure gasolines. These evaporation losses are separated into three categories:

1—Loss in filling the tank.

2—Loss from the car tank during driving and non-driving periods.

3—Loss from the carburetor bowl during driving periods.

The operation of filling the fuel tank of a car is similar to filling any fixed-roof atmospheric pressure type of storage tank. Losses here were calculated by the formula previously noted for determining the losses in filling cone-roof tanks and underground service station tanks. Losses in filling fuel tanks estimated in this manner are summarized in Table 3 for various vapor-pressure gasolines under typical summer, winter and intermediate-season temperatures.

Tests on the evaporation losses occurring from gasoline tanks of cars under driving conditions were made in connection with two previously reported vapor-lock programs on higher vapor pressure fuels. These were the Pawhuska road-test series conducted in 1937 by the Natural Gasoline Assn. of America and the Western Petroleum Refiners Assn., and the Nowata road-test program conducted in 1947 by the Natural Gasoline Assn. of America.

Typical evaporation-loss results from the two road tests were studied and, while it was found that the losses from the two tests were not directly comparable, the losses were found to be quite large, and of the

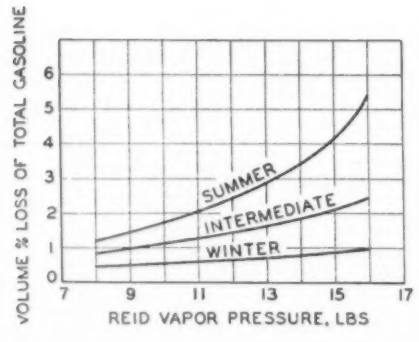

Fig. 1—Filling and storage losses from refinery to service station tank

TABLE 4—Handling Loss Values for Selected Conditions, Refinery to Service Station Tank

Season	Reid Vapor Pressure (Pounds)	Loss (Per Cent by Volume of Total Gasoline)	Loss (Per cent by Volume of Incremental Butane)
Summer	8	1.78	...
	10	1.73	15.1
Intermediate	10	1.11	...
	12	1.46	11.5
Winter	12	0.69	...
	14	0.80	3.6

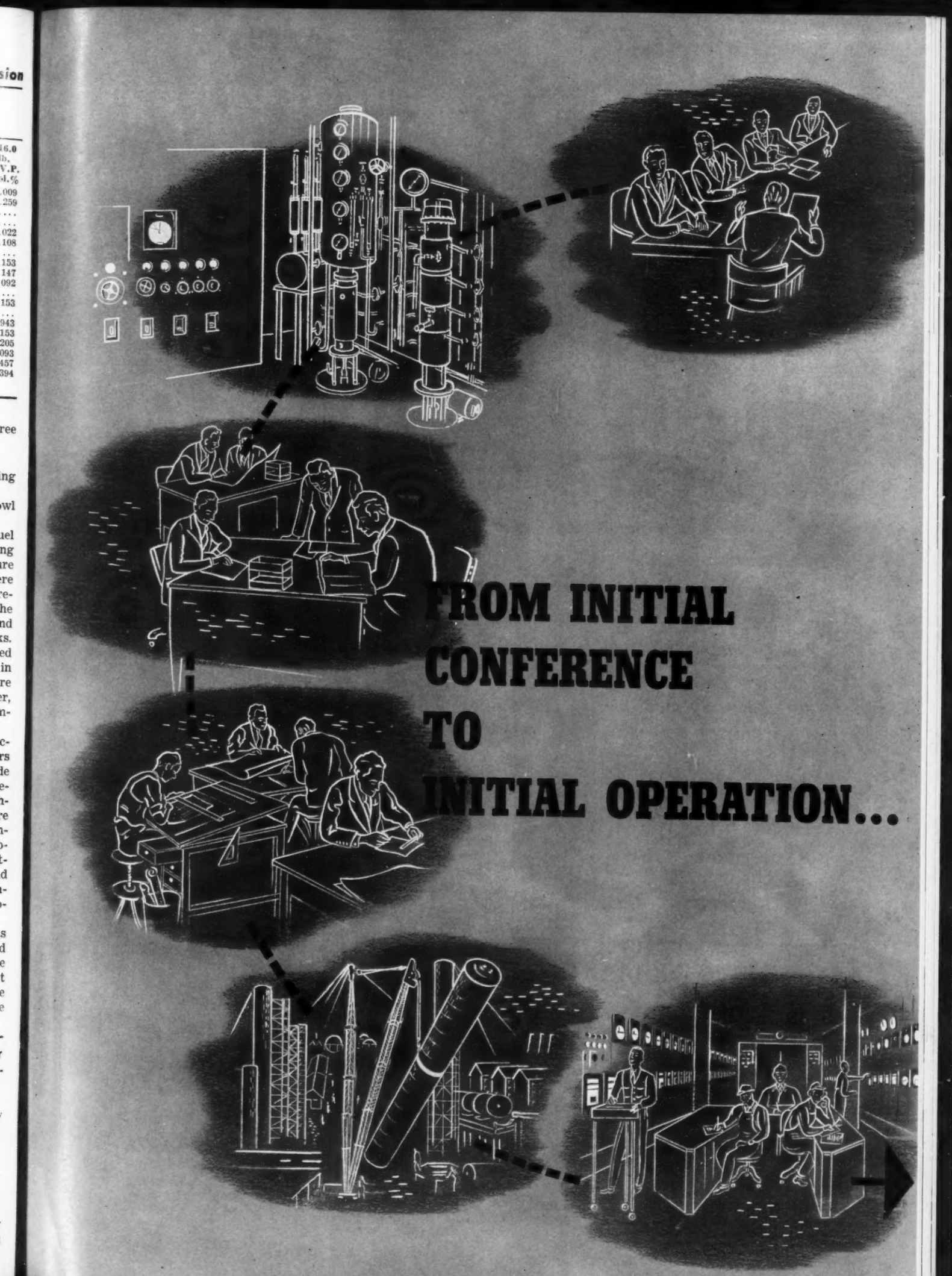
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TABLE 5—Results of Paulsboro Road Tests on Evaporation Losses from Automobile Gasoline Tanks

Car	Reid Vapor Pressure, lbs.	Avg. Temp. ° F.	True Vapor Press. psi.	Length of Test, Days	Mileage miles/week	Loss, Vol. % 15 gals/week
1.....	11.4	57.9	5.65	3.67	275	0.13
	11.4	55.8	5.45	6.88	297	0.30
	11.4	51.9	5.00	11.71	176	0.29
2.....	11.4	58.7	5.75	5.00	260	0.76
	11.4	53.0	5.15	12.00	134	0.72
3.....	13.6	59.3	6.85	4.71	163	0.86
	13.6	53.2	6.05	11.73	177	0.60
4.....	13.6	52.3	5.95	2.65	145	1.23
5.....	8.6	51.5	3.75	2.62	262	0.22
6.....	8.6	51.2	3.75	2.65	338	0.17
	8.6	50.0	3.65	8.00	343	0.14

same order of magnitude as all of the losses arising in the course of transporting fuel from the refinery to the service station.

Evaporation losses occurring under driving conditions, however, represent only a portion of the overall evaporation losses occurring from the gasoline tank of an automobile, as most automobiles are idle far more hours than they are driven.

In order to evaluate the evaporation losses from automobile gasoline tanks under a reasonable ratio of driving to idle periods, a series of tests was undertaken in the vicinity of Paulsboro, N. J., using six late-model cars, fueled with gasolines of 13.6, 11.4, and 8.6 RVP.

At the start of each test the gasoline tanks were filled approximately half full of test fuel and during the test period the car was entirely operated on gasoline from an auxiliary tank. Thus the regular car fuel tank was isolated during the test period.

Samples of fuel were taken from the tank at the beginning of the test and at intervals during the test period, by water displacement. The losses were determined by changes in the density of the fuel. A calibration of per cent loss vs. density was made on samples taken at the start of the test with each car.

The results of the Paulsboro tests are summarized in Table 5, wherein the losses are expressed as a volume percentage of the 15 gal. of gasoline consumed per week. These losses are appreciably less than the losses under driving conditions as reported in the Pawhuska and Nowata road tests.

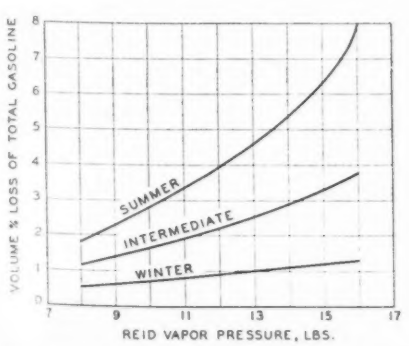

Fig. 2—Filling and storage losses from refinery to automobile tank

TABLE 6—Typical Seasonal Evaporation Losses, Refinery Through the Automobile Tank

Season	Reid Vapor Pressure (Pounds)	Loss (Per Cent by Volume of Total Gasoline)	Loss (Per Cent by Volume of Incremental Butane)
Summer	8	1.78	...
	10	2.74	31.2
Intermediate.	10	1.68	...
	12	2.27	19.2
Winter	12	0.93	...
	14	1.09	5.0

TABLE 7—Typical Carburetor Evaporation Losses

Season	Reid Vapor Pressure (Pounds)	Loss (Per Cent by Volume of Total Gasoline)	Loss (Per Cent by Volume of Incremental Butane)
Summer	8	0.25	...
	10	1.25	33
Intermediate .	10	0.53	...
	12	1.53	33
Winter	12	0.09	...
	14	1.09	33

The correlation of the Paulsboro road tests was used to establish the gasoline tank losses listed in Table 3 for fuels of various vapor pressures at summer, winter and intermediate season temperatures. The total evaporation losses occurring from the refinery through the automobile tank are plotted in Fig. 2 and typical losses during the various seasons are shown in Table 6.

The loss of the incremental butane fraction which occurs in moving the gasoline from the refinery through the automobile tank is larger in the summer, smaller in winter, and about the same in the intermediate season as the loss which would be encountered if the excess butanes were converted to gasoline by alkylation or catalytic polymerization.

As part of the overall study the extent of losses of gasoline from the carburetors of automobiles was examined from data taken during the Pawhuska road tests of 1937 under driving conditions and it was assumed that losses under non-driving conditions would be negligible since the carburetor holds such a small amount of gasoline. Typical carburetor losses are as given in Table 7, this data being that used in Table 3 in estimating the total loss from service station to use. Carburetor losses are shown as small under nor-

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TABLE 8—Typical Seasonal Evaporation Losses Occurring from Refinery through Carburetor of a Car

Season	Reid Vapor Pressure (Pounds)	Loss (Per Cent by Volume of Total Gasoline)	Loss (Per Cent by Volume of Incremental Butane)
Summer	8	2.04	...
	10	3.99	64
Intermediate .	10	2.21	...
	12	3.80	52
Winter	12	1.03	...
	14	2.18	38

mal conditions but increase sharply in all seasons with increasing gasoline vapor pressures.

The total evaporation losses occurring from the refinery through the carburetor of a car are plotted in Fig. 3 and summarized in Table 8.

"These total losses of the incremental butane are expressed as per cents by volume", the paper states. "However, inasmuch as no chemical changes are involved, these percentages also represent the energy losses of the incremental butane fractions and, as such, indicate that the energy losses brought about by increasing gasoline vapor pressures are appreciably higher in all seasons than

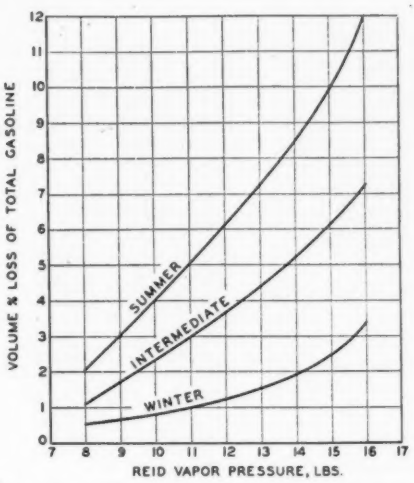


Fig. 3—Filling and storage losses from refinery to combustion in the automobile engine

would be encountered in alkylation or catalytic polymerization.

"In comparing methods of utilizing butanes, some allowances have to be made for the natural resources other than petroleum necessary to convert butanes into gasoline by alkylation or polymerization. Appreciable amounts of steel, concrete, chemicals and manpower are required to construct and operate these conversion plants.

"From the standpoint of the *overall* conservation of natural resources, higher energy losses can, therefore, be tolerated when excess butanes are included directly in gasoline than when they are chemically converted to gasoline. The difference in losses between the two procedures that exists at the breaking point is extremely difficult to evaluate. However, in making these comparisons, the existence of some margin must be recognized."

It is concluded that, when all of the evaporation losses in gasoline operations from manufacture to ultimate use are considered, higher energy recoveries could be made by converting excess butanes to gasoline by chemical means than by direct inclusion of them in gasoline. However, if only the losses occurring from manufacture to the purchase of the gasoline by the consumer are considered, the situation is reversed.

(1) Numbers of tables and charts do not correspond with the numbers in the original paper.

(2) J. Happel and D. P. Heath, *Oil Gas J.* 41 (46) 160 (1943).

Natural-Gas Butane and Motor-Fuel Vapor Pressures

By R. C. ALDEN and T. W. LEGATSKI
Phillips Petroleum Co., Bartlesville, Okla.

A REVIEW of a paper under the same title presented before the 13th Mid-Year Meeting of the API Refining Division, Philadelphia, Pa., May 13, 1948

THE past and present picture of butane from natural gas sources was studied at length to make possible some forecasts as to probable future supplies of natural-gas butane.

The volume of butane resulting from modern complex refining operations was estimated in arriving at a total overall picture for butane, but the refinery aspects of the butane situation in detail were recognized as beyond the scope of the study.

Relationships developed in the company's laboratories, based on many analyses of natural gases, were used as a basis for estimating the potential butane in natural gas.

Present practices in the petroleum and natural gas industries are reffered to as greatly increasing the potential availability of butanes today. New crude oil production coming from deeper horizons is generally associated with higher crude-oil gravities, higher gas-oil ratios and, consequently, with relatively larger quantities of light fractions.

The past few years also has seen the development on a large scale of gas-condensate types of high-gravity production. Apart from the condensate produced as such, the cycling operations resorted to in the efficient production of condensate reservoirs have provided a new source of gas for natural-gasoline and butane-extraction operations. Much of the increase in natural gasoline production in the past few years is attributable to the cycling operations on condensate pools. A very substantial proportion of the industry's total proved reserves is now reported to be of condensate character.

Expanding markets for natural gas have caused a rapid increase in the volumes of gas being withdrawn from essentially gas-bearing formations. Such gases are, of course, treated for the removal of condensable hydrocarbons before they are turned into the transmission systems. The light hydrocarbons extracted in such operations particularly the "butanes and heavier" represent further additions to the total currently available supply. Further expansion of gas-treating operations is anticipated.

Petroleum refining operations have also witnessed marked changes which should have some effect on the butane availability problem. Cracking operations are now more closely keyed to octane number than to yields. We have seen the widespread adoption of catalytic cracking, polymerization and of alkylation.

The increased incentive to extract

THE AUTHORS

Mr. Alden

R. C. Alden, director of research, Phillips Petroleum Co., Bartlesville, graduated from Lehigh University in 1918 and served as a lieutenant in World War I. He started in the oil industry in 1920 in Oklahoma, and engaged in research work and plant engineering and operations in the natural gasoline industry. In 1925 he joined the research staff of Phillips, and in 1930 was made assistant director of research; in 1933 he succeeded to the directorship.

Mr. Legatski

T. W. Legatski, assistant director of research, Phillips Petroleum Co., graduated from the University of Michigan and during 1920-25, was also a teaching assistant and research assistant in the Department of Engineering Research. He went with the Phillips company in 1925 as research engineer, was supervisor of the Burbank research station, and was made assistant director of research in 1929.

propane from refinery vapors to satisfy expanding liquefied petroleum gas markets has supplied butane as a byproduct of the extraction for use either as polymerization charge stock or as a direct blending agent. These various changes in refinery processing methods have either served to give us new volumes of light hydrocarbons, or means of utilizing the volumes.

To permit ready application of the information developed in the study in presenting the picture of the future potential availability of natural-gas butanes, all findings were reduced to a common basis of "barrels per barrel of crude processed". This method of presentation had the advantage of permitting the ready addition of the volume of butane produced in refining operations to those produced from natural gases. (The word "butane" as used in the paper denotes C_4 hydrocarbons.)

Through studies of the components of motor fuel produced for the period 1936-46, it was developed that the 1946 ratio of potential butane from natural-gas sources to the crude oil "pentanes plus" gasoline has increased about 27% over that of 1936. "Although this may seem to be a small amount at first glance," the paper states, "it should be remembered that the total production of pentanes plus gasoline from crude oil in 1946 was almost 50% greater than it was in 1936.

"The 50% increase in pentanes plus gasoline production from crude oil was still not enough to soak up the new volumes of butane potentially available from natural-gas sources.

"With a continuing trend toward the processing of more and more natural gas for fuel purposes, and the processing of more high-gravity crude in refineries with relatively more drastic reforming for octane improvement, it can only be concluded that the trend toward further increases in the ratio of natural-gas light fractions to the primary refinery product will continue."

What this increase in the ratio of potential butane from natural gas to crude oil pentanes plus means currently can best be expressed in terms of vapor pressure of the finished gasoline. The results of a vapor-pressure study indicated that the motor-fuel vapor-pressure level required to permit the incorporation of only the butane content of processed natural gas, with no provision for the inclusion of any butane from other sources, was about 11 lb. in 1936 and about 12.5 lb. in 1946, an increase of 1.5 lb.

In considering the probable future trends in the availability of a natural-gas butane, Table 1 (Table 6 in the original paper) compares 1946 production of crude oil and natural gas with proven reserves as of Dec. 31, 1946 in terms of their butane potentials. It is noted that the 1946 reserves have a considerably larger ratio of natural gas and natural-gas butane than the 1946 production. Reserves of natural-gas butane amount to 30.4% of the motor fuel in the crude oil reserves at the 1946 yield of motor fuel from crude oil.

"This amounts to a literal flood of natural-gas butane", it is stated, "but is based only on 1946 reserves of natural gas and crude oil. When one undertakes to project the trends of new discoveries of natural gas and crude oil into the future, the figures on potential natural-gas butane supplies climb to still greater proportions, for the reason that new reserves of natural gas are being found at a more rapid rate than new reserves of crude oil are being discovered."

The conclusion is inevitable that, as critical as the best utilization of natural-gas butane may be today, it is certain to become considerably more critical during the remaining years of life of our petroleum sources.

Among the uses for butane for purposes other than motor fuel blending, the liquefied petroleum gas industry is discussed because of its rapid growth. Except for certain chemical and other special uses, propane can be substituted for butane in the various LPG outlets.

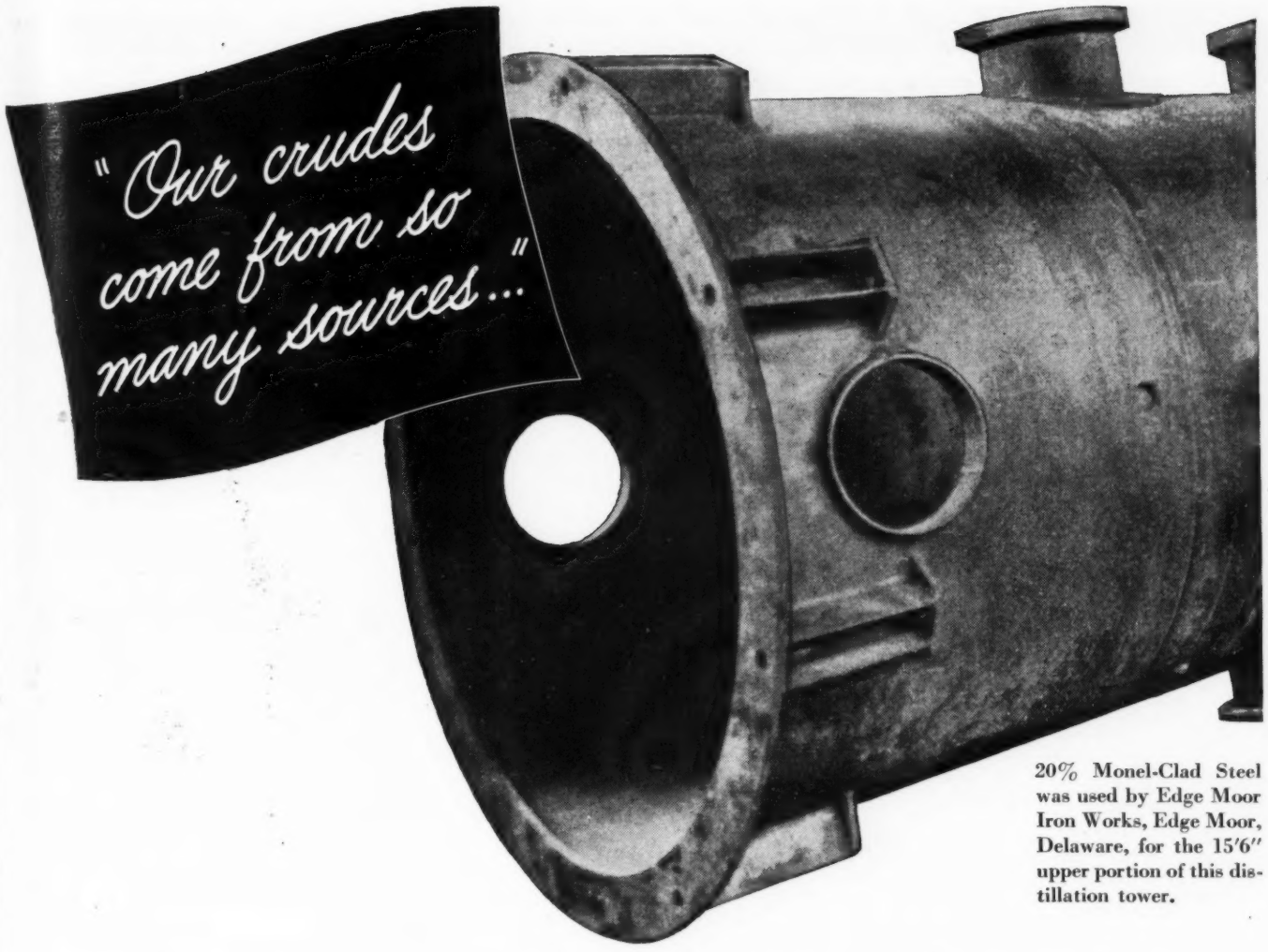
It is concluded, in regard to LPG in its relation to butane supply, that, although growing quantitatively, it is shrinking relatively. It is not a large factor in the butane demand ledger and can become much smaller.

The authors have hazarded a few guesses as to the refinery aspect of the butane situation, in order to arrive at their overall picture for butane:

1. Butane in crude oil as received at refinery 1.0%.
2. Synthetic butane produced in refinery operations, per cent of crude runs to stills 3.7%.
3. Butane in motor fuel, annual average 6.0%.
4. Approximately one-third of refinery butane used as polymerization and alkylation feed stock. A little comes from natural-gas sources.
5. The vapor pressure of composite "pentanes and heavier" motor fuel is approximately 5.2 lb.

TABLE 1—Comparison of Natural-Gas Butane Availability—1946 Production vs. 1946 Reserves

	1946 Production	Reserves as of 12-31-46
1. Crude oil, millions bbls.	1,733	21,345
2. Motor fuel, millions bbls.	766	9,450
3. Natural gas, trillions of cu. ft.	4.0	160.6
4. Cubic feet of natural gas per bbl. of crude oil	2,310	7,520
5. Butane in natural gas, millions of bbls.	71.6	2,870
6. Barrels of butane per bbl. of crude oil	0.041	0.139
7. Bbls. of natural-gas butane per bbl. of motor fuel at 1946 yields of motor fuel	0.094	0.304
8. Vapor pressure of motor fuel when only all natural-gas butane is included, lbs.	12.45	23.85+



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6. Each per cent butane added to refinery gasoline raises the vapor pressure approximately 0.8 lb.

With the above assumptions and with the statistical data available from its study, a supply-use balance for butane from all sources was constructed on the basis of 1946 data, as given in Fig. 1. Various elements of uncertainty exist both as regards supply and use, and to indicate this uncertainty, the tops of the supply and use bars are left open. The most uncertain element of the diagram is the quantity of synthetic butane made in processing crude oil at refineries.

Another important uncertainty is the amount of butane going to alkylation and polymerization and the effects on the butane-motor-fuel balance of these refinery operations; another is the actual portions of refinery and natural-gas butane going to the various uses.

"The diagram is self-explanatory", the paper states, "particularly in regard to quantities and origins of butane. The three scales between the supply and use bars show the percent of total potential butane supply, the vapor pressure of motor fuel if the indicated quantities of butane are incorporated, and the percentage of butane in motor fuel at the indicated quantities of butane inclusion.

"The outstanding fact to be derived from the chart is that only about 30% of the potential butane finds its way directly into motor fuel. Only 44% of the butane liquefied finds its way directly or indirectly into motor fuel. The other 56% of the butane goes to relatively low-value uses.

"Parenthetically, as has been pointed out earlier, these low-value uses have sustained, and currently are sustaining, very substantial investment programs. Only about 65% of the potential butane is liquefied, which provides considerable room for the further expansion of liquefaction installations, particularly if the financial incentive were motor-fuel rather than fuel values.

"Another important fact to be derived from the diagram is the very large magnitude of the potential butane supply, which was 8.8% of the crude oil run to stills in 1946. Of the available butane supply, 107,000,000 bbl. were not used as motor fuel. This is equivalent to 240,000,000 bbl. of crude oil at the 1946 gasoline-yield ratio. If it were possible to divert all the butane to motor-fuel uses, it would have the effect of increasing our crude-oil reserves by 6,250,000,000 bbl. over the life of our known crude-oil reserves which, in turn, would have the effect of prolonging the life of the crude-oil reserves from 13 to 16 years.

"The improvement in automotive fuel systems to provide satisfactory operation with fuels of 1 lb. more in Reid vapor pressure would have permitted the inclusion of 9,700,000 bbl. more of butane, which is equivalent to 21,700,000 bbl. of crude oil at the 1946 gasoline-yield ratio.

"Thus the failure to have taken this relatively small step required 4½ days' extra crude supply and refinery operation in 1946. It is interesting to speculate on what could have been done about the burner-oil shortages with 4½ extra days of refinery operation. Over the remaining life of our known crude-oil reserves the total extension of life would have been 166 days, or 5½ months."

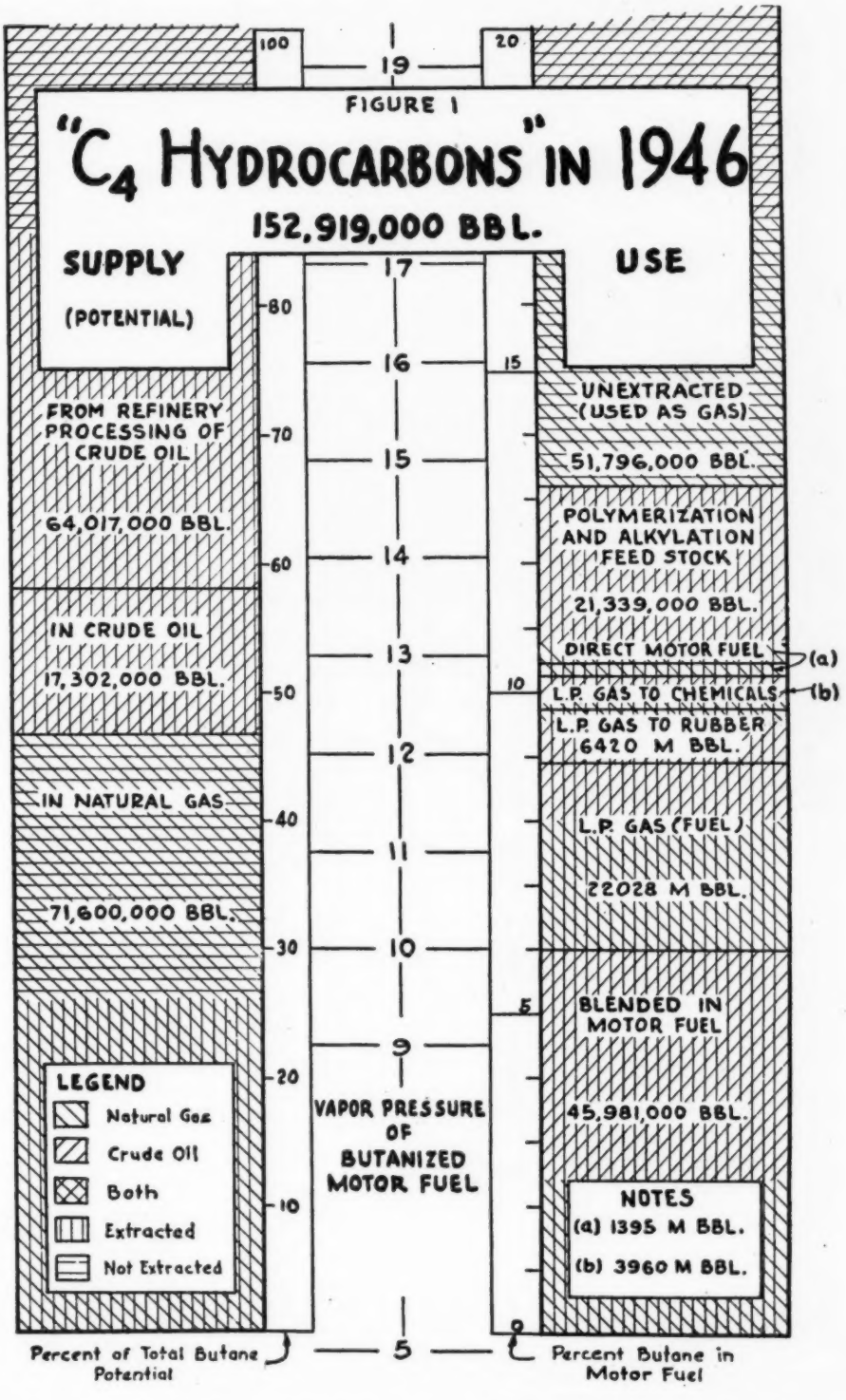

Fig. 1—Supply-use balance for butane from all sources, based on data available for 1946

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Refiners who have selected furfural for solvent treatment of petroleum products during the past fifteen years have found that they are traveling the road of safety, economy, efficiency, and quality. Excellent yields of premium quality lube oils are the rule for all users of this solvent process. Today more lube oil is being refined with furfural than by any other solvent process.

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Write for Bulletins 201 and 203 describing furfural. Price, specifications, and further information concerning furfural are available upon request. Questions invited.

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CATALYTIC POLYMERIZATION And Its Commercial Application

By P. C. WEINERT and GUSTAV EGLOFF
Universal Oil Products Co.

Catalytic polymerization units for conversion of propylenes and butylenes to high-octane gasoline are of three types: low-pressure regenerative; small high-pressure chamber type; tubular unit, where closer catalyst temperature control is secured with a circulating medium. Pretreatment of feed for removal of sulfur compounds is by countercurrent contact with caustic solution; for removal of nitrogen compounds by contact with a stream of water in a countercurrent plate or packed tower.

Water must be present in the feed to maintain the required equilibrium to prevent the catalyst from becoming dehydrated. The effect of process conditions on the normal commercial polymerization operation is described. Also given are properties of polymer gasoline from nonselective polymerization of propylene-butylene mixtures in the three types of units.

CATALYTIC polymerization is a basic refinery process for the conversion of light olefin gases to a gasoline product which has a high octane value. Over 100 units are in commercial operation at present in many refineries throughout the world. Installations range in size from those processing 250,000 cu. ft. per day of fresh feed gas to the largest one processing 15,000,000 cu. ft. per day. The total daily polymer production from all polymerization units is estimated to be 39,000 b/d.

The charge stock for the process consists of the gases produced from thermal or catalytic cracking of heavy oils or straight-run naphtha fractions. The propylene and butylenes in these gases, when contacted with the proper catalyst, will polymerize to form a high-octane number product which boils in the gasoline range. The process in effect converts low value refinery by-product gas into a valuable product and at the same time improves the efficiency of the refinery as well as the quality of the gasoline produced.

The catalyst used is the "UOP Polymerization Catalyst." It is a combination of kieselguhr and phosphoric acid in the form of 1/4 x 1/4-in. cylindrical pellets. This catalyst has also been used in commercial operations to alkylate aromatics with olefins for the production of ethyl, propyl, and butyl benzenes, and to promote the addition reaction of hydrogen sulfide to an olefin to produce mercaptans.

The polymerization of propylene and butylenes can be accomplished at varying conditions of temperature and pressure, depending on the equipment used and type of product desired. Where the maximum yield of polymer product is desired, all of the available propylene and butylenes are processed at conditions such as to obtain almost complete conversion of the olefins to gasoline. This type of operation is commonly referred to as nonselective polymerization.

On the other hand, either the propylene or the butylenes can be processed as a separate fraction to produce more selective products. For such operations the polymerization conditions are carefully controlled to obtain the maximum yield of the product desired. For instance, isobutylene and normal butylenes can be polymerized under controlled conditions to yield a polymer consisting largely of iso-octenes which on hydrogenation will have an octane rating of 90-96. This hydrogenated product is valuable as a blending component for the production of aviation fuels. Likewise the polymerization of propylene can be controlled to favor the yield of hexenes, nonenes, or duodecenes, depending on the product specification required.

Sources of Feed Stocks

Olefin feeds for catalytic polymerization originate for the most part from thermal and catalytic cracking operations that process reduced crudes, gas oil, and straight-run naphthas for the production of motor fuels. Olefin feeds can also be obtained from propane or butane fractions by use of the UOP catalytic dehydrogenation process or by the thermal cracking of these fractions.

Although it is the object of all oil processes to produce a maximum yield of gasoline from a given amount of charge, the nature of the operation is such that a certain percentage of the charge is inevitably converted to gaseous hydrocarbons which cannot be included in the gasoline products. That portion of the gas so produced which can be utilized within the refinery as a fuel receives a value credit based on the value of fuel oil required to give an equivalent heat output. Any gas in excess of that required as fuel is burned at a flare and therefore serves no useful purpose. At best, the net gas produced from cracking operations prior to preparation for charging to a polymerization unit, has a value equivalent to the lowest value product in the refinery. Thus the economic justification for polymerization is based on the fact that the process converts a low value material into a high-octane gasoline which generally bears the highest value per unit volume of all the products.

The method for collecting the feed for polymerization will depend on the type of gasoline recovery system used in conjunction with the cracking operation. The type of polymerization unit employed will in turn depend on the source, quantity and olefin content of the feed to be processed.

In general, the total products from cracking operations are separated into different products in a fractionating tower, the overhead from which consists of the net gasoline make as well as all the light gases. In the case of most high pressure thermal cracking operations the main fractionator overhead receiver will operate at 50 to 100 psi., making it possible to recover the greater portion of the available propylene and butylenes in solution with the liquid separated in the receiver. As is to be expected, the greater the receiver pressure, the greater the solubility of the propylene and butylenes in the receiver liquid, and the less will be the concentration of these olefins in the gas phase.

That portion of the light gas which is not retained in solution with the net liquid separated in the receiver must be vented as a gas from the receiver. This gas stream, commonly referred to as distillate receiver gas,

is generally scrubbed countercurrently with raw feed or an absorption oil taken as a side stream from the main fractionator. The absorption operation prevents loss of the lighter gasoline components such as pentane and amylenes and recovers sufficient butanes and butylenes to permit producing a gasoline product of the desired volatility and vapor pressure.

The receiver liquid consisting of the net gasoline produced plus that portion of the gas soluble in the liquid phase at the operating pressure is pumped into a gasoline stabilizer or debutanizer column. It is the function of the stabilizer column to effect such a separation of the light gases from the distillate receiver liquid as will produce finished gasoline. The control of product volatility is obtained by regulating the operation of the column in order to include a certain percentage of butanes and butylenes in the finished gasoline.

The residual light ends which are not retained in the gasoline are removed from the column as an overhead stream. This stream may be recovered in the form of liquid or gas depending on the pressure at which the column is operated or on the adequacy of the cooling system to cool the overhead to the point of complete condensation. Thus in the case just described, the gas produced from the conventional high pressure thermal cracking operation consists of the absorber lean gas, and the gasoline stabilizer net overhead liquid or gas stream. The typical distribution of the olefins in these streams from a conventional high-pressure thermal cracking unit is shown in Table 1.

TABLE 1—Typical Distribution of Olefins In Streams from Conventional High-Pressure Thermal Cracking Unit

	Absorber Lean Gas	Stabilizer Gas
Hydrogen	3.3	...
Methane	27.7	2.0
Ethylene	5.2	1.0
Ethane	26.7	11.2
Propylene	7.6	13.3
Propane	22.8	27.6
Butylene	1.0	22.4
Butane	5.7	21.5
Pentanes and heavier	...	1.0
	100.0	100.0
Propylene & butylene, mol %	8.6	35.7

For 65 psi absorber pressure the ratio of absorber gas to stabilizer gas is approximately 2.0:1.

As indicated in Table 1, roughly two-thirds of the total net gas made from the cracking operation is released from the unit as absorber lean gas; however, the greater portion of the propylene and butylenes are concentrated in the remaining one-third of the net gas vented from the unit as stabilizer net overhead. In general, the yield of 10-lb. RVP polymer from processing the total gas from topped crude cracking operation will be between 4 and 4.5% of the cracking unit charge. The yield of 10-lb. RVP polymer from a polymerization operation charging only the stabilizer gas from the same cracking operation unit having an absorber operating at between 70 and 90 psig. will normally amount to from 3 to 3.5% of cracking unit charge.

When the cracking operation is carried out at low pressures, as in the case of vapor phase thermal cracking and catalytic cracking, the distillate receiver, which collects the main fractionator overhead products, is of necessity operated at a pressure close to atmospheric. The majority of the light hydrocarbons as well as a portion of the normally liquid gasoline is carried out of the receiver as a gas. The total gas and liquid products from the low pressure distillate receiver are brought up to a higher pressure. The compressed gas and the pumped liquid are brought together and cooled to as low a temperature as possible with the available cooling water. The total gas and liquid products are then passed through a vessel where a separation of gas and liquid is effected at the high pressure. The gasoline recovery and stabilization is, in most cases, then carried out in manner similar to that for the high pressure cracking operation.

Through the use of the polymerization process the propylene and butylenes present in a portion or all of the net gas from the cracking operations can be polymerized to yield a high octane gasoline product which represents a gain in gasoline yield as well as a gain in over-all product octane number.

Catalytic Polymerization

The UOP catalytic polymerization process is flexible in that a wide range of olefins can be polymerized. As with any other process, a study of the increase in value of the product over the

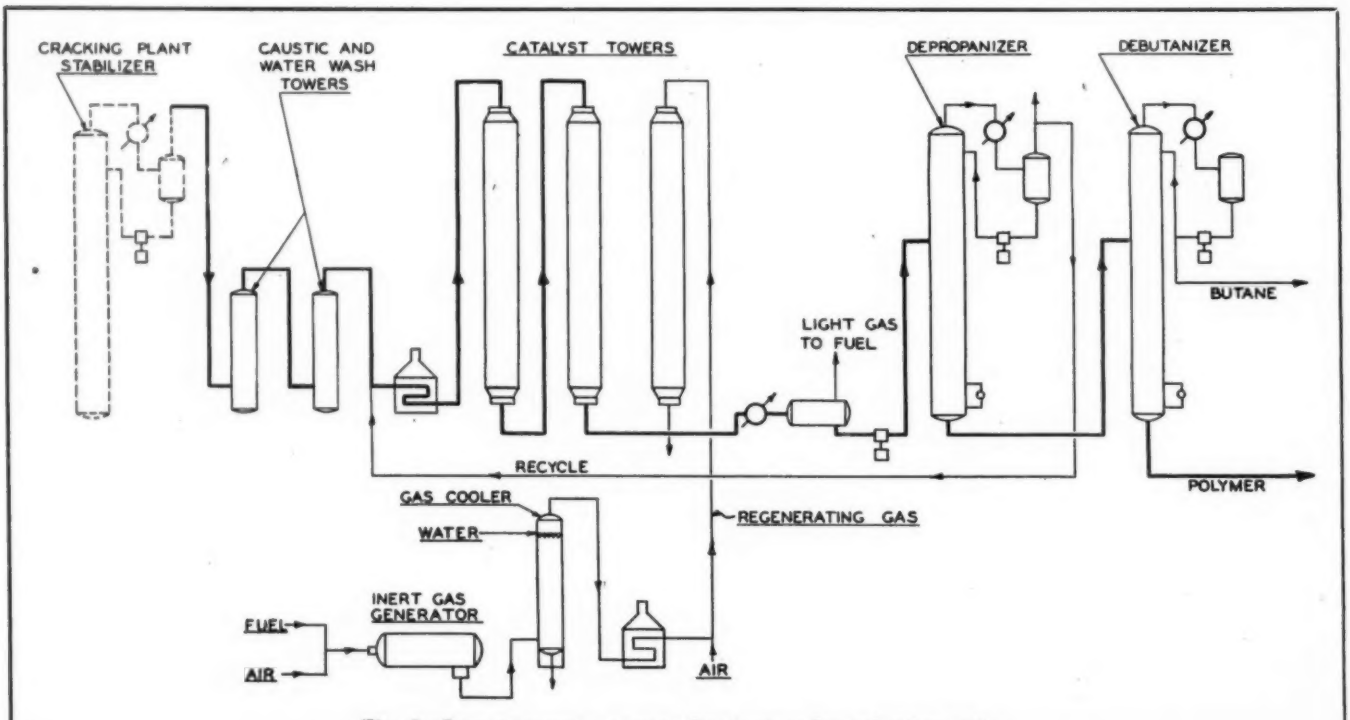

Fig. 1—Low pressure regenerative type polymerization unit.

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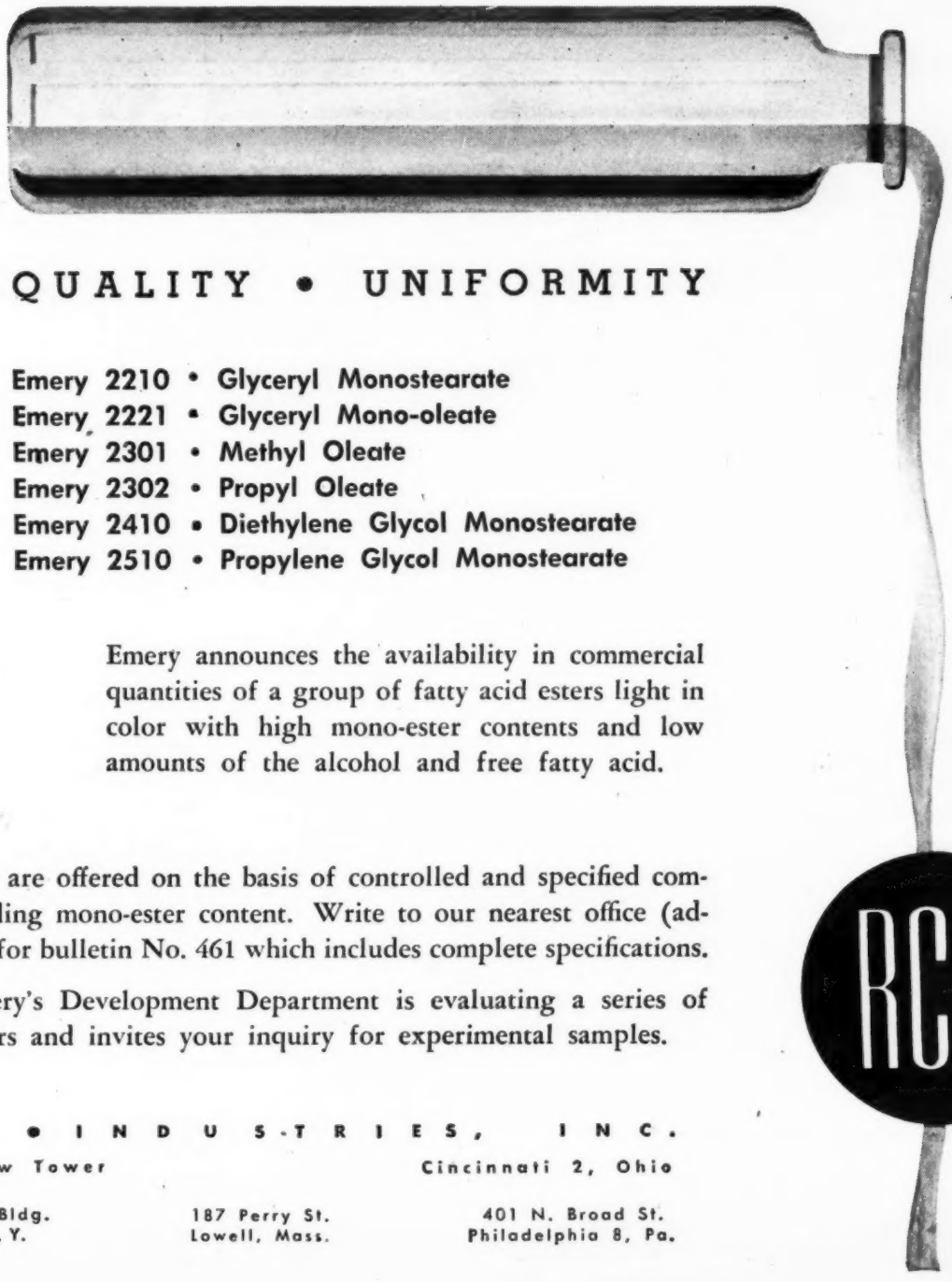

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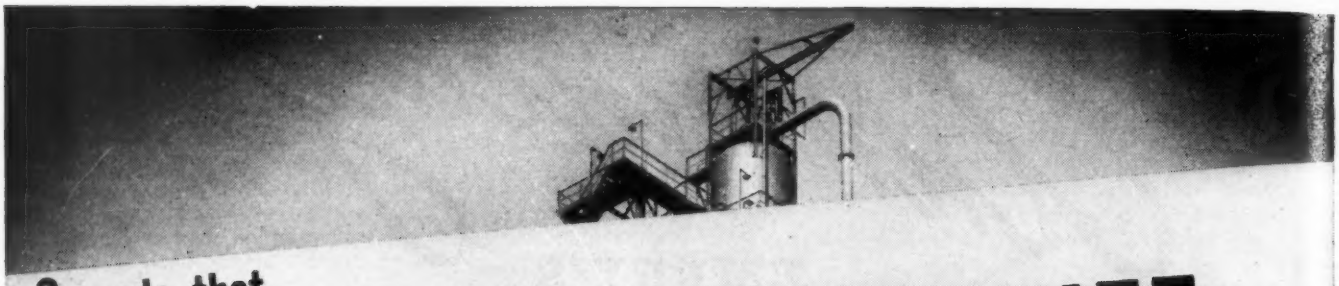

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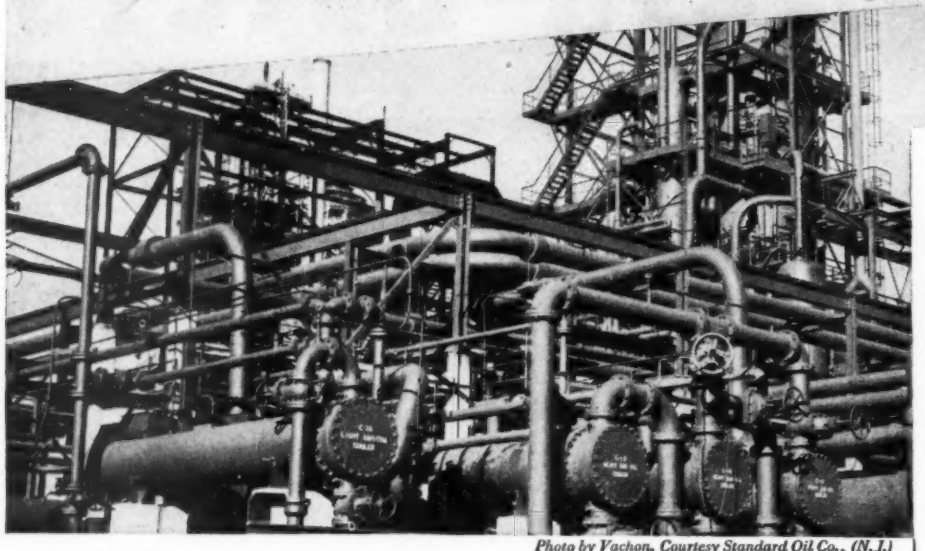

Photo by Vachon. Courtesy Standard Oil Co., (N.J.)

Every seven months, sulfuric acid ate away the heat exchanger tubes in one refinery.

Frequent replacement of equipment proved expensive. So refinery engineers began a series of tests with other corrosion-resistant metals.

Tests prove helpful

On the basis of test results, the engineers made this recommendation: *"Change to Monel*."*

Now—with Monel tubes—the refinery gets 43 months of life *in the same service where other tubes averaged only seven.* (See Co-Polymer Plant history in panel.)

Performances like this aren't unusual. Nor are they confined to sulfuric acid applications.

Many refinery uses

Monel withstands a wide range of refinery corrosives. For example:

- *hydrogen sulfide*
- *hydrochloric acid*
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- *impure or brackish waters*
- *oil, wax and solvent mix*

Monel also resists hydrofluoric acid in HF alkylation; it serves dependably under high-temperature, high-pressure conditions in feed water heaters; withstands attack in caustic soda reboilers and in condensers for chlorinated solvents and furfural.

Long life, low cost

Wherever corrosive conditions are severe, consider using Monel. It may help you increase equipment life, speed up production, and cut maintenance and replacement expense.

"Change to Monel" PAYS DIVIDENDS

Co-Polymer Plant

Monel tube bundle installed in reactor feed precooler. (121 tubes, ¾" OD x 180" x 14 BWG.)

Product Handled — Butane and 70% sulfuric acid outside tubes; butane inside.

Temperatures — Entrance to tubes: 115°F.
Exit from tubes: 145°F.
Entrance to outside: 160°F.
Exit from outside: 150°F.

Service Life — Previous material lasted 7 months; Monel tubes 43 months.

Ketone Dewaxing Unit

Monel tube bundle located in charge cooler. (754 tubes, ¾" OD x 144" x 16 BWG.)

Product Handled — Oil, wax and solvent mix outside tubes; water inside.

Temperatures — Entrance to tubes: 90°F.
Exit from tubes: 120°F.
Entrance to outside: 180°F.
Exit from outside: 110°F.

Service Life — Previous material lasted 31½ months. Monel tubes in service 67 months to date. Still in good condition when inspected. No plugged tubes.

Caustic Plant

Monel tube bundle located in second effect, caustic evaporator. (712 tubes, 2" OD x 48½" x 16 BWG.)

Product Handled — Steam from first effect outside tubes; caustic soda and sodium chloride inside.

Temperatures — Entrance to tubes: 172°F
Exit from tubes: 172°F.
Entrance to outside: 240°F.
Exit from outside: 240°F.

Service Life — All but 15 of the original 721 Monel tubes installed in 1928 are still in service. (The 15 were replaced because of failure of lap-weld seam.) Previously-used material had an average life of 10 months.

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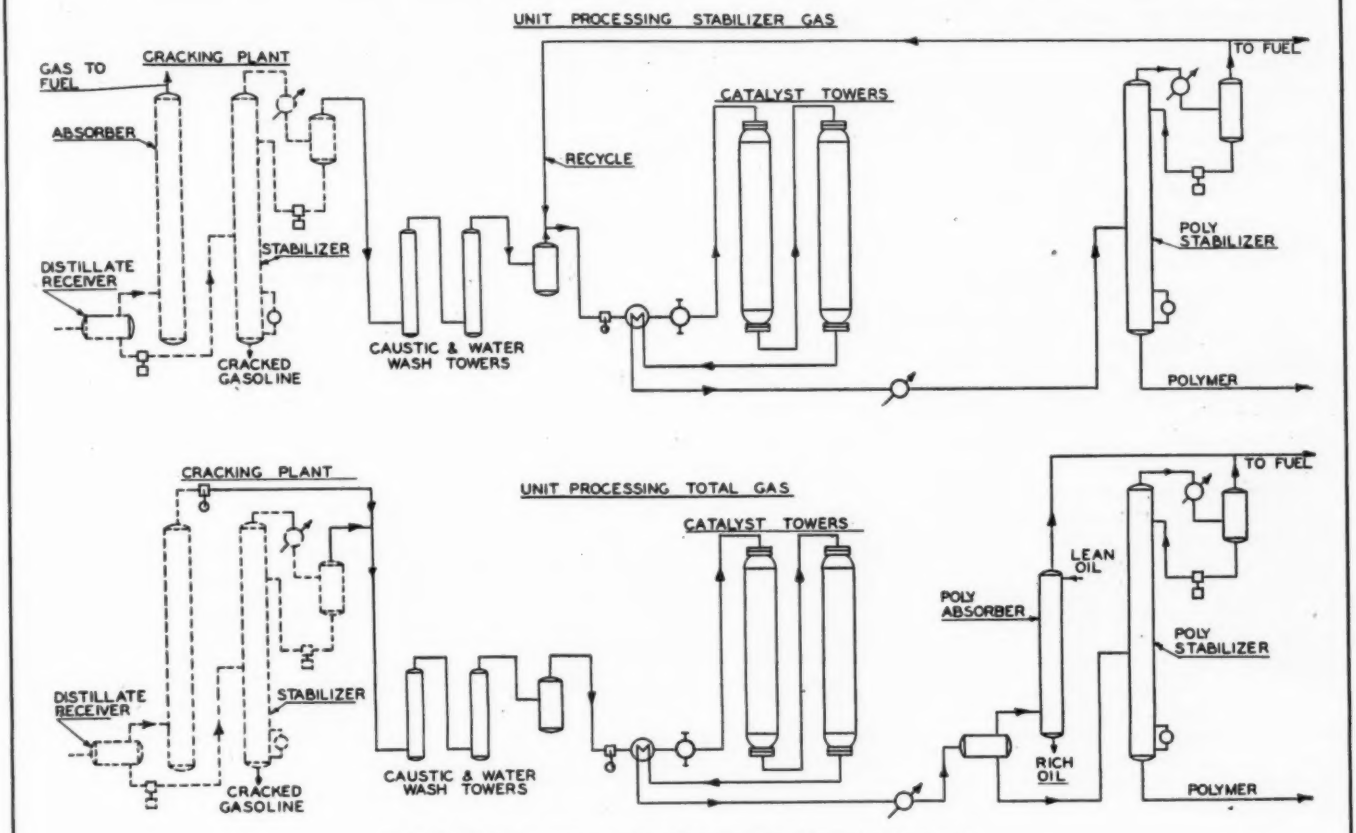

Fig. 2—High pressure chamber type polymerization unit

raw material, weighed against the cost of the plant required to carry out the process, is the determining factor in deciding which olefins are to be polymerized. For most refineries the economics are such that the polymerization of all the propylene and butylenes is a profitable operation.

There are some exceptions to this, however, since in some refineries the butane remaining after the polymerization of all the butylenes would be insufficient to make it possible to meet the desired over-all product volatility. In such cases some of the butylenes could be included in the gasoline as product having gasoline value; consequently, the polymerization of these butylenes, which results in a volume shrinkage, would not be justifiable. On the other hand, at some refineries casinghead gasoline can be obtained at a price such that it can be profitably blended in with the cracked gasoline. In these instances all the butylenes, along with the propylene, can be polymerized to obtain the maximum gasoline yield and the over-all gasoline product volatility can be adjusted by the addition of casinghead gasoline.

The UOP catalytic polymerization process is fundamentally simple, the principal operation being that of contacting the olefin-containing feed with the polymerization catalyst at the proper conditions of temperature and pressure. In its simplest form a polymerization unit involves the use of a pump or compressor to bring the feed liquid or gas stream, as the case may be, to the desired operating pressure. The feed is then heated to the desired operating temperature and passed through one or more catalyst towers for a given contact time. The reaction product is then cooled and the polymer gasoline is separated from the unconverted light gases.

The polymerization reaction is exothermic; therefore provision must be made to permit control of catalyst temperature. Usually this is accomplished by recycling a portion of the lean gas from the unit to dilute the olefin content of the stream going to the catalyst tower. Alternatively the design of the unit may embody provisions for removing the heat of reaction from the reaction zone by heat exchange with a cooling medium.

Types of Polymerization Units

Catalytic polymerization units are of three types. Each type has been found to have special application depending on the quantity and character of the gas to be processed.

The first polymerization units installed are of the low pressure regenerative type. A flow diagram is shown in Fig. 1. These units were designed to handle the gas released from the cracking plant gasoline stabilizing system, processing the gas at the line pressure and making use of the available differential pressure to force the gases through the catalyst towers.

These units were therefore operated at a pressure slightly below the cracking plant stabilizer pressure. Although they had the advantage of not requiring compression of the available feed, this was offset by the fact that at low pressures the tendency for fouling of the catalyst surfaces is greater than at high operating pressure, consequently requiring periodic regeneration of the catalyst.

The regeneration involves burning off the carbonaceous deposits by passing an inert gas containing a small quantity of oxygen over the catalyst, the concentration of oxygen being regulated to control the temperature of regeneration. The regeneration step is followed by steaming to restore the catalyst to the proper state of hydration for maximum activity.

The cost of the auxiliary equipment required for the regeneration of the catalyst on the low pressure units was such that polymerization units could be economically justified only for large installations that processed a minimum of 2,000,000 to 3,000,000 cu. ft. of gas a day.

The low pressure type nonselective

polymerization unit design was eventually discontinued in favor of a high pressure unit design when it was learned that, at high pressures in the order of 500-750 psig., the rate of catalyst fouling is reduced to the point that satisfactory catalyst life can be obtained without periodic regeneration.

In order to make possible the use of the catalytic polymerization process for small refineries that produce between 250,000 and 1,000,000 cu. ft. of olefin bearing gases, small high pressure units were designed. A flow diagram of this type of unit processing either stabilizer gas or total gas is shown in Fig. 2. This type of unit, known as a "midget" high pressure chamber type poly unit, was a simple operating unit requiring very little equipment, and, once built, requiring very little operating attention. Because of the simplicity of the process and the relatively small capital investment required, its economic evaluation, balancing increased gasoline yield versus erection costs, was extremely favorable. In many cases the unit paid for itself in less than 12 months of operation. Of over 100 "poly" units built, there are 54 "midget" type units.

The high pressure chamber type unit has two distinct advantages over the earlier low pressure type unit. Because of the higher operating pressure in the neighborhood of 500 psig. the density of the material processed is greater, and this has the effect of maintaining the catalyst clean and relatively free from coke-like deposits. Although in time the catalyst will accumulate carbonaceous deposits and other impurities which will decrease its activity, this point is not generally reached until after the catalyst has produced 75 gals. or more of 10-lb. RVP polymer per pound of catalyst.

Since this catalyst life is greater than that normally obtained on the low pressure units and since the cost of new catalyst is low, the cost of regeneration of catalyst cannot be justified for this style of unit. When the catalyst becomes spent it is discarded and the catalyst chambers reloaded with fresh catalyst.

The high pressure unit has the advantage that a smaller quantity of catalyst is required to obtain the required contact time between catalyst and a given quantity of feed. Consequently the catalyst chambers are considerably smaller in size. Also the number of chambers required is less since one of the catalyst chambers in the low pressure units is always out of service undergoing regeneration.

Operation at the higher pressure favors the polymerization of the olefins; therefore, higher olefin conversion figures are obtainable on the high pressure units.

TABLE 2—Typical Operating Conditions for Three Types of Polymerization Units Processing C_3-C_4 Mixture

	Chamber Type Low Press. Regeneration	High Press.	Reactor Type
Pressure, psi.....	250	500	900
Catalyst temp., °F.			
Inlet	400	375	400
Outlet	475	450	415
Olefin contents, %			
Fresh feed	35	35	35
Combined feed	20	20	35
Spent gas	10	5–7	4
Olefin conversion, %.	80	85–90	92
Catalyst life, gal./lb. catalyst	50	75+	150

The third type of unit used for catalytic polymerization is the tubular or reactor unit. A flow diagram is shown in Fig. 3. This unit has been designed to provide for closer catalyst temperature control than can be obtained in the chamber type unit. The catalyst is contained in a multiplicity of small tubes surrounded with a circulating cooling medium used to achieve temperature control by removing the heat of reaction as it is liberated along the length of travel of feed over the catalyst. The design of the reactor section will depend on the order of temperature control to be attained. Catalyst tube sizes have ranged from 2 to 5 in. I. D.

Where 5-in. tubes have been used each tube is provided with an individual cooling jacket with the cooling medium coming from and discharging to common headers serving a set of parallel tubes manifolded together as a unit called a reactor. Where smaller diameter tubes are used the reactor is built in the manner of a vertical heat exchanger. The catalyst is loaded into the tubes and the cooling medium circulates through the jacket or shell, the line of flow being parallel to the tubes.

The reactor type unit is technically preferable to the other types described because of the advantage of higher pressure operation as well as reaction temperature control. Another advantage is that longer catalyst life is obtainable as a result of maintaining closer control of reaction temperature. Typical operating conditions for the three types of polymerization units described are shown in Table 2.

Treatment of Feed

The gas or liquid stream of gaseous hydrocarbons available as feed to a polymerization unit will most generally require some treatment for removal of either sulfur compounds or nitrogen compounds or both. The sulfur compounds commonly existing as hydrogen sulfide or mercaptans must be removed in order that the polymer produced will be low in sulfur content and have maximum utility as a blending component for premium gasolines. The nitrogen compounds must be removed from the feed before it is processed by the catalyst, since these compounds are basic in character and will reduce its catalytic activity.

Although some feeds are naturally low in both sulfur and nitrogen compounds, this is the exception rather than the rule, for in most cases a complete feed pretreatment train is required in conjunction with the polymerization unit to remove product contaminants and catalyst poisons.

The removal of sulfur compounds from feeds can be accomplished by countercurrent contact with a solution of caustic. When the sulphur content of the poly feed is high—in excess of 350-400 grains per 100 cu. ft.—a regenerative-type hydrogen sulfide removal process may be used. The hydrogen sulfide removal step is followed by a contact with caustic for the removal of the mercaptans. The caustic can be regenerated by heating and in some cases the regeneration of the caustic used for mercaptan removal from the cracked gasoline and from the poly feed is carried out in a common regenerator.

Since most nitrogen compounds, particularly those which act as catalyst poisons, are soluble in water,

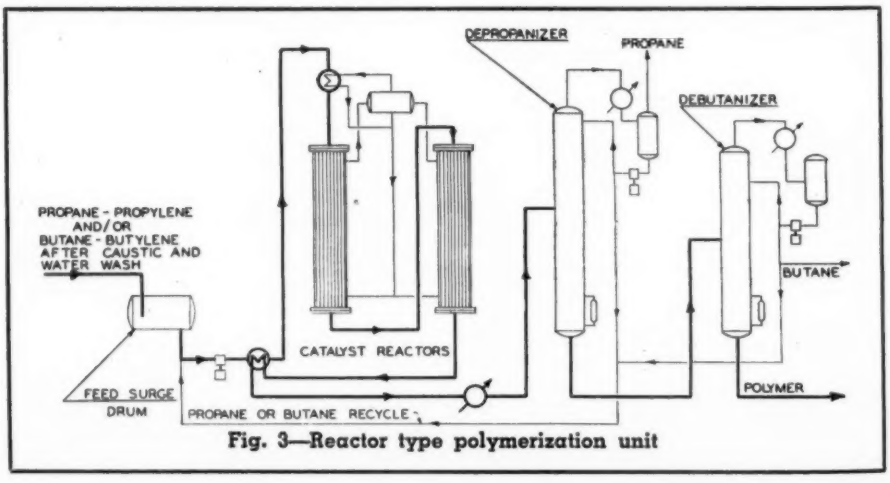

Fig. 3—Reactor type polymerization unit

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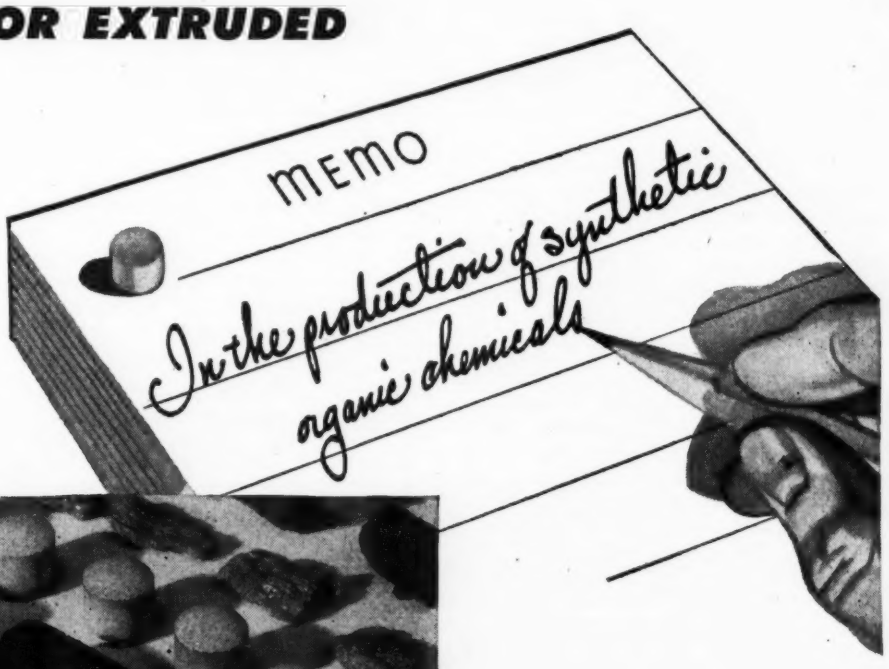

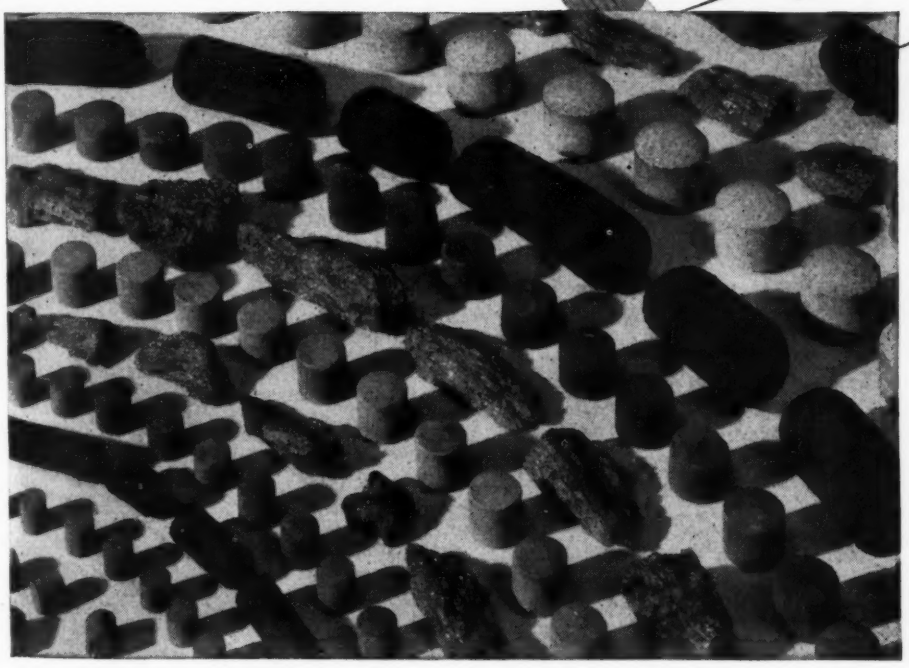

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the removal of such compounds can be accomplished easily by providing a good contact of the feed with a stream of water. This contact is most effectively accomplished in a countercurrent plate or packed tower.

Process Factors

The polymerization reaction is influenced by factors such as operating temperature, pressure, time of contact and activity of the catalyst. Optimum operation results only from the proper choice of those variables which can be considered as independent variables.

The normal feed to a polymerization unit produced from thermal or catalytic cracking will contain propylene and butylenes. When the total gas or the stabilizer gas from the cracking operation is processed over polymerization catalyst, the propylene and butylenes will be interpolymerized to produce a mixed polymer commonly referred to as a nonselective polymer. Under proper conditions of operation 90-95 % of the propylene and butylenes will be converted to a gasoline product. Likewise, when the propylene or the butylenes are available as separate fractions, either of these olefins can be polymerized to yield a polymer gasoline suitable for blending with other refinery gasoline products. Inspections of typical polymers from the polymerization of propylene and butylenes and mixtures of the two are shown in Table 4.

The individual olefins vary in the degree of ease of polymerization. Comparing the olefins, propylene, isobutylene, and normal butylenes in the order of their ease of polymerization, the isobutylene is the most reactive. The normal butylenes are next in the order of reactivity, followed by propylene. Although propylene is more difficult to polymerize than either the iso- or normal butylene, when polymerized in conjunction with the butylenes, it has been found to polymerize as readily as the normal butylene. In such operation the butylene appears to have a promoting effect on the polymerization of propylene.

Although pentane fractions containing amylenes can be satisfactorily handled individually under special operating conditions, the presence of small quantities of amylenes in a C_3-C_4 feed is not considered favorable since the light C_5 fraction will generally contain an appreciable quantity of di-olefins which are harmful from the standpoint of catalyst life.

When polymerizing butylenes under the proper conditions of temperature and pressure the reaction can be so controlled as to produce iso-octenes, which on hydrogenation are converted to iso-octanes generally used as high-octane aviation gasoline base component. In this reaction all of the isobutylene, together with a portion of the normal butylenes, is converted. Since the octane number of the hydrogenated product is directly dependent on the amount of normal butylenes which are polymerized with the isobutylene, the quality of the product can be controlled at the desired level by limiting the amount of normal butylene polymerized. The hydrogenated product, consisting chiefly of isomeric octanes, will have an octane number in the range of 90-96.

In an operation where iso-octenes are the products desired the polymerization of butylenes is limited by selecting the operating conditions which will so limit the degree of reaction that a maximum yield of dimer would be produced. Likewise, by setting conditions to promote greater reaction, the polymerization of butylene can be directed toward the production of a trimer. A typical summary of a selective-polymerization operation, showing the properties of the charge and products, operating conditions, and yields, is shown in Table 3.

For the most part the product from the polymerization of propylene and butylenes will resemble a normal gasoline. A typical distillation of such a polymer is shown in Table 4. In the polymerization of these olefins, however, a small quantity of high boiling polymers is produced along with the polymers boiling in the gasoline range. Under normal conditions this represents but a small portion of the total polymer. Under unfavorable conditions, however, a portion of this heavy polymer may remain on the catalyst and be further converted to higher molecular weight polymers which resemble heavy tars and in some cases even have the appearance of a coke-like material.

Since the accumulation of these materials will plug catalyst voids, reducing the catalyst activity, it is important that conditions be such as to keep the tars washed off the catalyst surfaces. The use of high pressures will favor the maintaining of a clean catalyst by virtue of the fact that under conditions of elevated pressures some dense phase will be present to keep heavy polymers in solution and prevent them from depositing on the surfaces of the catalyst. It can readily be seen, therefore, that the lower the molecular weight of the feed being processed, the higher the pressure required to obtain those conditions which favor the production of a dense phase wash within the catalyst zone.

Pressure not only favors the maintenance of a clean catalyst but also favors high olefin conversions. Low temperatures are favorable to the maintenance of a clean catalyst; therefore the optimum temperature for any given operation will be no greater than that sufficient to maintain the desired conversion of olefins. In general, where the plant is provided with sufficient catalyst, the temperature range will be 350-425° F.

The polymerization reaction is exothermic, the heat liberated amounting to some 670 Btu per pound of propylene polymerized and 450 Btu per pound of butylenes polymerized. The heat of reaction will depend, of course, entirely on the type of reaction which takes place. The figures given represent an average of the heat of reaction which should be accounted for in the design of units intended for motor fuel production.

High temperatures affect the catalyst in much the same manner as low pressures in that such conditions are influential in increasing the amount of tar and coke deposits on the catalyst. High temperature operation will also result in over-polymerization which will be evidenced by the generally higher boiling range of the polymer product.

A certain amount of water must be present in the feed in order to maintain an equilibrium within the catalyst tower such that the catalyst will not become dehydrated. In some cases the feed, as a result of prior contact with water, will contain sufficient water in solution for this purpose. In cases where this is not true, water must be added to the feed in accurately measured quantities to maintain the required equilibrium.

Since the amount of water which must be present in the gas being processed over the catalyst is necessar-

TABLE 3—Typical Selective Polymerization Operation

Total feed to plant	B/D	Olefin Content iC_4H_8	Olefin Content nC_4H_8
Fresh butane-butylene charge	740	23.8	32.0
Spent butane-butylene recycle	417	3.8	20.0
Combined charge	1157	16.8	25.5
Products			
Iso-octenes			
Dimer	210		
Trimer	22		
Reactor operating conditions			
Pressure, psig.	900		
Temperature			
Inlet °F.	330		
Outlet °F.	350		

Product quality

	Iso-octene Dimer	Trimer
Specific gravity	.734	.773
Initial B.P., °F.	210	261
5	219	281
10	223	286
30	226	302
50	228	329
70	230	357
90	234	379
95	237	402
End point °F.	257	434
% sulfur	.004	

Hydrogenated iso-octene
ASTM octane number clear—95.1

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ily a function of the temperature and pressure at which the catalyst operates, it can readily be seen that catalyst temperature and hydration control go hand in hand. In a reactor type unit where the catalyst is maintained at essentially isothermal conditions the water content of the feed is adjusted to maintain the catalyst in the proper state of hydration for any given level of operating temperature.

In a chamber type unit where a temperature rise exists across each catalyst bed the water content of the feed is adjusted to satisfy the water requirements of the catalyst which is operating at the lowest temerature. In order that the catalyst operating at the highest temperature in any bed shall not become overly deficient in water the operation of the unit is controlled to limit the temperature rise. In this manner the reaction is distributed among the catalyst beds and the water requirements of the catalyst operating at temperatures higher than that existing in the first bed are satisfied by adding water between the individual beds.

Underhydration of the catalyst favors the formation of coke on the catalyst and in extreme cases where almost dry feeds are processed, the catalyst can become inactive in short times.

Since catalyst hydration is an important variable in the operation of polymerization units, it is essential that proper attention be given to the control of the water fed to the polymerization unit. Overhydration will result in softening and eventual plugging of the catalyst beds. The carry-over of water into the catalyst beds resulting from misoperation should be guarded against, for wetting of the catalyst to the point where phosphoric acid is leached out can result in severe corrosion of the catalyst vessels, subsequent piping, and exchangers.

In the design of a polymerization unit, proper attention must be given to the amount of catalyst which is to be provided to process a given amount of feed. Attention should also be given to the arrangement of the catalyst in the unit in order to utilize linear velocities which are considered optimum for good operation.

When catalyst is used at optimum conditions of temperature, pressure, and catalyst hydration, it should suffer very little decrease in activity during the period of operation. The presence of catalyst poisons in the feed can, on the other hand, materially affect the activity and life of the catalyst. Substances harmful to the activity of the catalyst are ammonia and amines, oxygen, butadiene, and excessive water. Ammonia and amines, being basic in character, will act to neutralize the acid in the catalyst, thereby rendering it inactive. The chemical reaction between basic substances and the acid in the catalyst will soften and gradually disintegrate the catalyst.

Although amines usually originate in the oil being processed, in some instances the nitrogen compounds may find their way into the poly plant as a result of the injection of ammonia in those units from which the feed to the poly plant is derived. These substances can be eliminated by a thorough contact of the feed with water in a countercurrent scrubbing system. Where basic nitrogen compounds are known to be present in large quantities, most effective removal can be obtained by the use of water having a controlled pH by means of sulfuric acid injection.

The presence of oxygen will accelerate the formation of tar and coke on the catalyst, reducing its activity and life. Since oxygen is not normally present in poly plant feed unless it is mechanically introduced in feed gathering or in the pretreatment section, provisions should be made to eliminate its introduction if found to be present. When the poly feed is obtained from catalytic cracking operations, oxygen is likely to be present in the light hydrocarbon gases in small quantities. In such cases the gas-gathering system should include a step to separate the inert gases as well as the lighter hydrocarbons such as ethane and methane before processing in the polymerization unit.

TABLE 4—Properties of Polymer Gasolines

1. Typical inspection of polymer produced from nonselective polymerization of propylene-butylene mixture

Distillation	Polymer from Low Pressure Unit operating at 250 psi.	Polymer from Chamber Type Unit operating at 500 psi.	Polymer from Tubular Type Unit Operating at 900 psi.
Gravity, ° API at 60°/F.	...	67.3	66.6
Initial B.P. °F.	102	90	90
10	127	143	146
30	189	202	202
50	226	225	228
70	264	258	264
90	372	367	330
End point, ° F.	486	422	400
Recovery	98	95	96
RVP, psi	10	11	10.9

2. Typical inspection of polymer produced from polymerization of butylenes and propylene as separate fractions

Type of operation			
Feed olefin	Butylene	Butylene	Propylene
Operation	Selective	Nonselective	Nonselective
Type unit	Reactor	Reactor	Reactor
Pressure, lb./sq. in.	1000 1000	1000 1000	1000 1000
Polymer distillation			
Gravity, ° API at 60 °F.	66.4	64.3	62.4
Initial B.P., °F.	136	78	144
10	207	152	204
30	225	238	244
50	230	258	266
70	239	...	284
90	276	379	330
End point, ° F.	400	416	402
Recovery	98.0	95	98
RVP, psi	3.2	11	4

3. Polymer—Normal bromine number in range of 130-150

4. Inhibitor susceptibility

Inhibitor Content	Induction period, minutes	Copper Dish Gum Mg./100 cc.
Clear sample	15	25
0.025% UOP No. 1	500–550	18
0.005% UOP No. 4	450–500	15

5. Octane numbers

10 pound Reid vapor pressure polymer

ASTM clear	82.5
+ 3 cc.'s TEL	85.0
Research method clear	97.0
+ 3 cc.'s TEL	100.0

6. Octane blending values of polymer

Polymer in 5-10% blends in Straight-run 110-120

Polymer in 5-10% blends in thermal cracked gasoline 95-100

7. Results of PONA Analysis on nonselective polymer

Analysis of typical polymer sample

Component	Liquid Volume, %	Cut No.
iC_4	Trace	
nC_4H_8	.4	
C_5H_{10}	5.8	
C_6	2.6	1
115-140° F.	.6	2
140-250° F.	64.2	3
250-338° F.	16.3	4
Bottoms	10.1	5

Cut No.	1	2	3	4	5
Molecular weight	72	80	95	120	142
Density	.6545	.6683	.7140	.7540	.7948
Bromine No.	169	181	157	127	110
Refractive index	1.37758	1.38874	1.41117	1.42997	1.44786
Dispersion	82.0	85.0	88.9	90.7	94.1
Diene content No.	.7	.7	....	....	....
% aromatic	0	0	.5	1.1	2.2
% olefins	76.2	90.6	93.2	95.4	97.6
% paraffin and naphthenes	23.8	9.4	6.3	3.5	0.2

Average of C_6 + fraction (cuts No. 2-5 inclusive)

	Per Cent
Aromatic	0.8
Olefins	94.1
Paraffins and naphthenes	5.1

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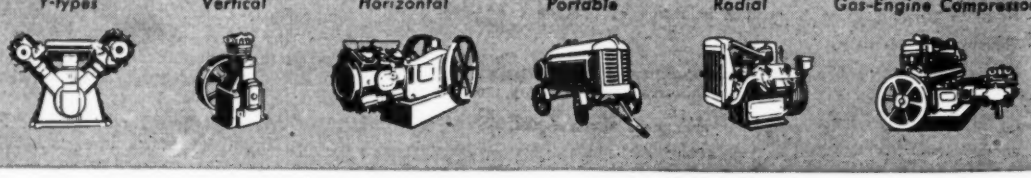


Patent Trends in Petroleum Refining

By PETER J. GAYLOR

Patent Attorney and Editor "The Technical Survey"

Hydrocarbon Synthesis Process Uses Oil-Borne Catalyst

NOW THAT THE commercial hydrogenation of carbon monoxide for the production of liquid fuels is almost an accomplished fact (justifying a feature article in a recent issue of *Fortune Magazine*), it would be desirable to discuss some of the patents being issued in this field, which has been attracting considerable and widespread interest in the daily press and around Washington.

Texas Co. (which is reported to have a 38% interest in Carthage Hydrocol, Inc.) recently was issued U. S. 2,440,109 on a method for hydrocarbon synthesis. A flow-sheet of the steps involved is shown in Fig. 1. Feed synthesis gas is drawn from line 1 through compressor 3 which forces it through heater 4a into reactor 7 where it meets a stream of catalyst in oil carrier entering through line 12. The gas bubbles in the oil-catalyst stream are forced inside tubes 8 which are cooled on the outside with cooling medium entering through line 30.

After passing through gas separator 13, the reaction stream enters fractionator 16 where light reaction products are distilled off. The heavy liquid may be destructively hydrogenated or otherwise treated in treating plant 33, or passed through cooler 22 and thence into standpipe 23 wherein the density is greater than in tubes 8 (since the latter contain gas bubbles, etc.). The oil-catalyst suspension is then recycled to reactor 7, after being fortified with additional fresh catalyst from make-up tank 10. Reaction temperature is about 375-400° F, with pressure up to 100 psi.

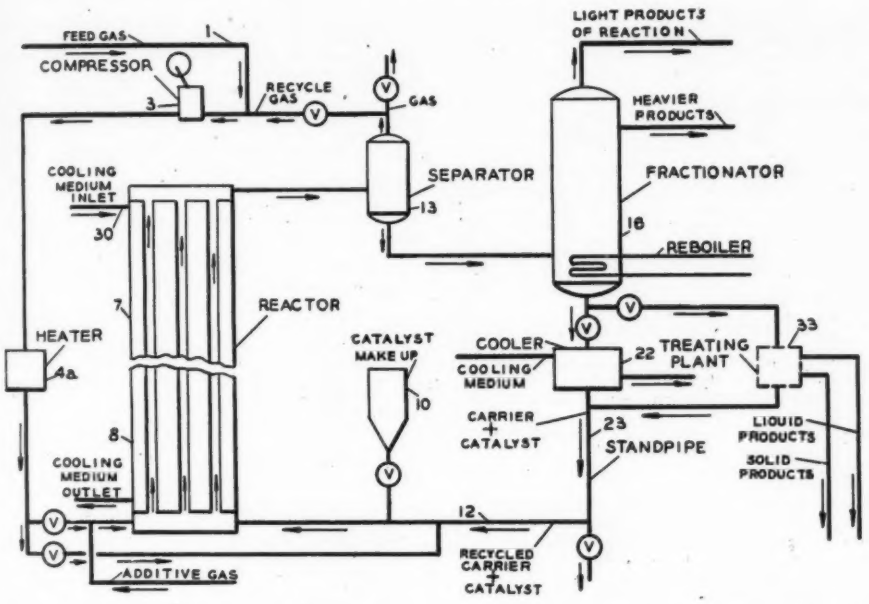


Fig. 1—Flow sheet of new Texas Co. patent on hydrocarbon synthesis (U. S. 2,440,109)

Hydrogen Fluoride Suggested For Flocculating Asphalt

A METHOD FOR flocculating asphalt, using hydrogen fluoride as the flocculating agent, is described by Socony-Vacuum Oil Co. in its U. S. 2,438,874. This compound is said to have many advantages over sulfuric acid, since it has a higher deasphalting effect for a given weight, its sludge is easier to handle and is readily dispersed in the raffinate. Furthermore, sulfuric acid tends to sulfonate the oil and, besides, it is a strong oxidizing agent.

Catalytic Cracking

ONE CRACKING PROCESS which was recently patented by Adsorptive Process Co. of Chicago (U. S. 2,436,495), provides for simultaneous regeneration of catalyst with steam to produce a gas of high fuel value. A typical analysis of such gas is said to be 32% methane, 12% carbon monoxide, 35% hydrogen and 11% carbon dioxide.

As can be seen from Fig. 2, feed coming in from pump 1 is preheated in coil 2 and pumped into reactor or cracking chamber 6. Simultaneously, fresh catalyst, in finely divided form, from hopper 7 is led through line 8 and injected at jet 9 with carrier hydrocarbon gas from line 13, into cracking chamber 6, together with recovered catalyst from line 10.

Spent catalyst from chamber 6 is

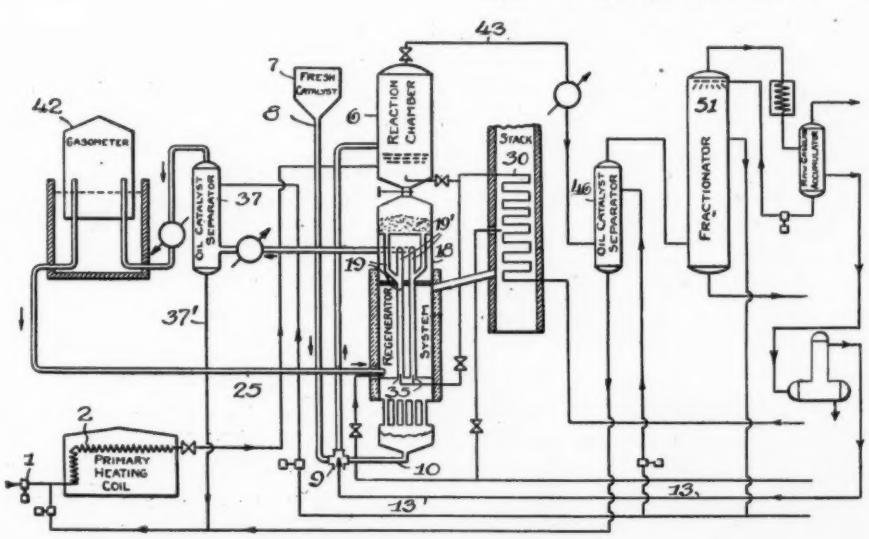
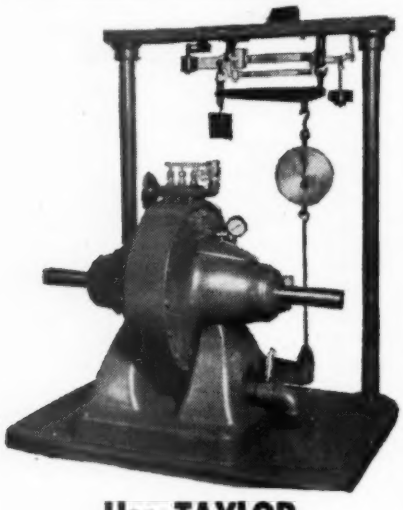


Fig. 2—Cracking process regenerates catalyst with steam to produce a gas of reported high fuel value (U. S. 2,436,495)

FOR ENGINE TESTS on FUELS & LUBES



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allowed to drop into a regenerator 18 and allowed to drop through pipe 19 counter-current to superheated steam introduced through jets 35. The regeneration gas is led through line 19 into oil separator 37 and gas holder 42, some of the fuel being drawn off through line 25 to be used as fuel for heating the regenerator system.

Cracked vapors from cracking chamber 6 are led through line 43 into oil separator 46 and fractionator 51. The steam used in the regeneration is superheated in stack 30.

Selected Patents

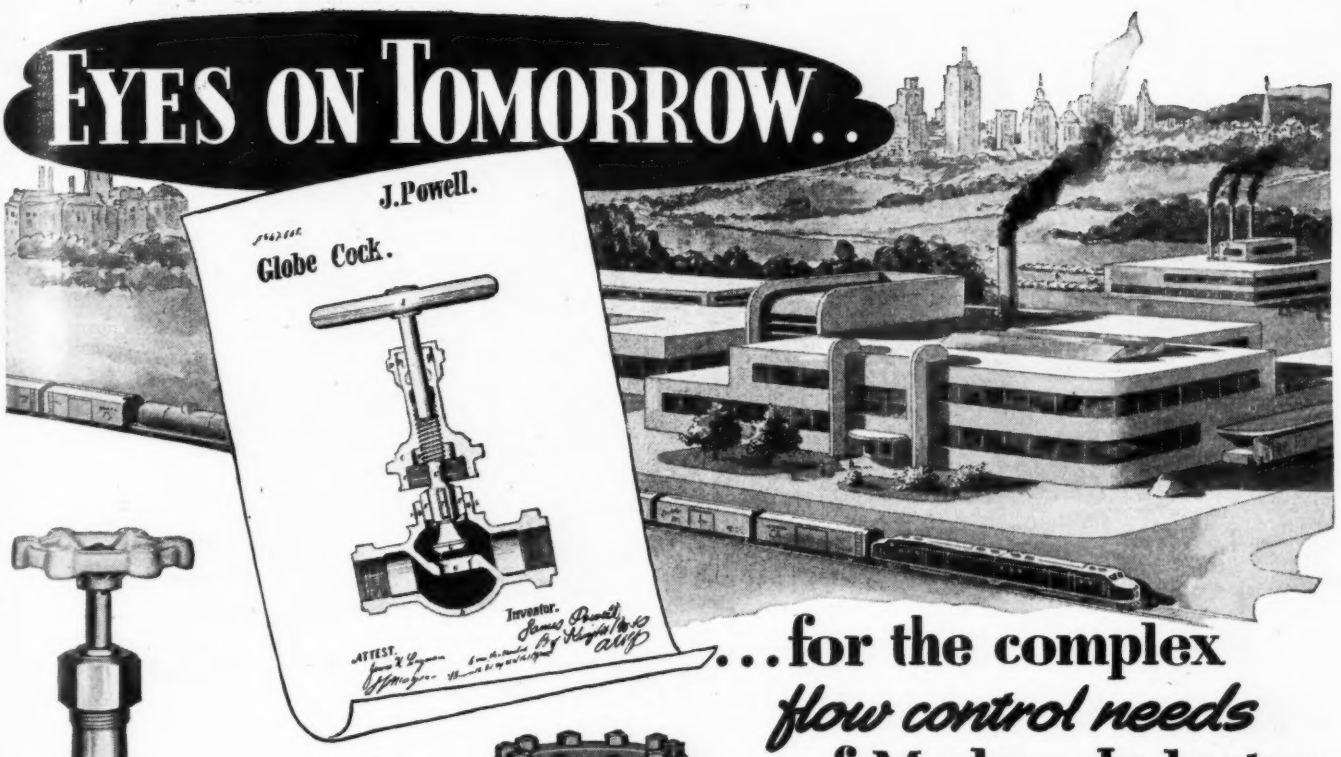
U. S. Patents issued from March 9, 1948 to April 27, 1948

U.S. 2,437,532 (Union Oil Co.) — Catalytic reforming
U.S. 2,437,533 (Union Oil Co.)—Catalysts.
U.S. 2,437,544 (Pure Oil)—HF Alkylation.
U.S. 2,437,600 (Du Pont)—Aldehydes by reacting olefins with carbon monoxide.
U.S. 2,437,828 (Tide Water Assoc. Oil) — Aromatic alkylation.
U.S. 2,437,930 (Shell Dev. Corp.)—Olefin oxides.
U.S. 2,437,948 (Anglo-Iranian Oil)—Isomerization.
U.S. 2,437,985 (Shell Dev. Corp.)—Thioketones.
U.S. 2,438,018 (Shell Dev. Corp.)—Alkali treating hydrocarbons.
U.S. 2,438,029 (Texas Corp.) — Catalytic conversion.
U.S. 2,438,041 (Phillips Petr. Co.) — Styrene from butadiene.
U.S. 2,438,215 (Univ. Oil Prods.)—Ethyl benzene.
U.S. 2,438,261 (Socony-Vacuum) — Conversion of fluid hydrocarbons.
U.S. 2,438,315 (Phillips Petr. Co.) — Dehydrogenating 2,3-dimethylbutane.
U.S. 2,438,434 (Union Oil Co.)—Ketone production.
U.S. 2,438,340 (Sun Oil Co.)—Low temperature polymerization of olefins.
U.S. 2,438,379 (Shell Dev. Corp.) — Catalyst production.
U.S. 2,438,398 (Sun Oil)—Cyclopentadiene.
U.S. 2,438,399-404 (Sun Oil)—Cyclopentadiene.
U.S. 2,438,421 (Texas Co.)—Isomerization.
U.S. 2,438,437 (Stand. Oil Dev. Co.)—Separating diolefins.
U.S. 2,438,439 (Stand. Oil Dev. Co.)—Chemical process for catalytic conversion of hydrocarbon oils.
U.S. 2,438,444 (Stand. Oil Dev. Co.)—Removing diolefins from olefins.
U.S. 2,438,445 (Stand Oil Dev. Co.) — Acid treating of cracked naphtha.
U.S. 2,438,446 (Stand. Oil Dev. Co.)—Lubricant and hydraulic fluid.
U.S. 2,438,449 (Stand. Oil Dev. Co.)—Synthesis of hydrocarbons and oxygenated compounds.
U.S. 2,438,451 (Stand. Oil Dev. Co.)—Activation of clay.
U.S. 2,438,452 (Pollock)—Diesel engine fuels.
U.S. 2,438,456 (Stand. Oil Dev. Co.)—Hydrocarbon conversion.
U.S. 2,438,461 (Stand. Oil Dev. Co.)—Cutting oil.
U.S. 2,438,464 (Rohm & Haas)—Catalytic process for butadiene.
U.S. 2,438,467 (Stand. Oil Dev. Co.)—Catalytic conversion.
U.S. 2,438,468 (Union Oil Co.)—Oxidation resistant oil composition.
U.S. 2,438,450 (Standard Oil Dev. Co.)—Drying microspherical gels.
U.S. 2,438,560 (Universal Oil Products)—Finely divided catalyst.
U.S. 2,438,569 (Universal Oil Products)—Alumina—Group VI oxide catalyst.
U.S. 2,438,570 (Universal Oil Products) — Toluene by catalytic cracking of monoalkyl benzenes.
U.S. 2,438,584 (Texas) — Non-sintered iron catalyst.
U.S. 2,438,599 (Monsanto Chemical. Co.)—E. P. lubricant.
U.S. 2,438,838 (Shell Dev.)—Thiophenols.
U.S. 2,438,890 (Standard Oil Dev. Co.)—Bitumin-coated fibrous material.
U.S. 2,439,021 (Phillips Petroleum Co.)—Alkylation.
U.S. 2,439,023 (Phillips Petroleum Co.)—Hydrocarbon conversion to ethylene.
U.S. 2,439,080 (Texas Co.)—Alkylating aromatics.
U.S. 2,439,301 (Phillips Petroleum Co.)—Isomerization.
U.S. 2,439,307 (Phillips Petroleum Co.)—Cyclopentadiene.
U.S. 2,439,348 (Socony-Vacuum) — Conversion of hydrocarbons.
U.S. 2,439,372 (Socony-Vacuum Oil Co.)—Hydrocarbon conversion.
U.S. 2,439,434 (Akt. Separator-Nobel)—Dewaxing oils.
U.S. 2,439,610 (Shell Dev.)—Stabilized organic composition.
U.S. 2,439,730 (Socony)—Cracking to produce olefins.
U.S. 2,439,734 (Phillips Petroleum Co.)—Lubricating oil additives.
U.S. 2,439,737 (Socony-Vacuum) — Aluminum bromide.
Re. 22,994 (Carter Carburetor)—Controlling pressure in combustion chamber.
U.S. 2,439,811 (M. W. Kellogg)—Catalytic conversion of hydrocarbons.
U.S. 2,439,812 (Socony-Vacuum)—Phenol by oxidizing benzene.
U.S. 2,439,819-21 (Standard Oil—Ohio)—High efficiency (E. P.) lubricants.
U.S. 2,439,852 (Carbide)—Catalyst revivification with HF.
U.S. 2,439,880 (duPont) — Tungsten-molybdenum trioxide catalyst.
U.S. 2,439,934 (Phillips Petroleum)—Aromatic hydrocarbons from paraffins.
U.S. 2,439,982 (Universal Oil Products)—Dehydrated castor oil.
U.S. 2,439,994 (Universal Oil Products)—Silica-aluminum-zirconia catalyst.
U.S. 2,440,000 (Socony-Vacuum)—Thickening drying oils.
U.S. 2,440,036 (Shell Dev.)—Catalytic alkylation of phenols by amines.
U.S. 2,440,109 (Texas)—Hydrogenation of carbon monoxide.
U.S. 2,440,233-4 (Socony-Vacuum)—Oxidizing benzene to phenol.
U.S. 2,440,258 (California Res.)—Refining petroleum distillates.
U.S. 2,440,286 (Shell Dev.)—Interpolymerization of isoamylenes with butenes.
U.S. 2,440,375 (Texas)—Lube oil containing methylol-forming aromatic.
U.S. 2,440,414 (Socony-Vacuum)—Cyclohexane from benzene.
U.S. 2,440,436 (Phillips Petroleum)—Catalyst chamber closure.
U.S. 2,440,442 and 51 (Phillips Petroleum)—Inhibiting polymerization of furfural.
U.S. 2,440,459 and 77 (Universal Oil Products)—Synthetic drying oil.

FOREIGN PATENTS (and Applications)

Brit. Appl. 24,285/46 (Filtrol Corp.)—Improved cracking catalysts.
Brit. Appl. 24,953/47 Lummus Co.)—Treating hydrocarbons.
Brit. Appl. 23,014/47 (Shell Oil)—Synthetic lubricants.
Brit. Appl. 23,130/47 (Shell Oil)—Acetaldehyde.
Brit. Appl. 23,359/47 (Shell Oil)—Hydrocarbon conversion.
Brit. Appl. 20,477/47 (Shell Oil) — Lubricants containing lead soaps of hydrogenated ricinoleic acid.
Brit. Appl. 20,152/47 (Socony-Vacuum) — Phenol.
Brit. Appl. 20,154/47 (Socony-Vacuum) — Nitriles.
Brit. Appl. 20,435/47 (Socony-Vacuum)—Amino alkyl derivatives of thiophenes.
Brit. Appl. 12,326-31/47 (Lubri-Zol Corp.) — Lubricating Compositions.
Brit. Appl. 27,448/46 (Koppers)—Dehydrogenation of alkyl aromatics.
Brit. Appl. 4,170/47 (Texaco Dev. Corp.)—Catalytic conversion.
Brit. Appl. 30,497/47 (Shell Oil)—Dehydro-pyridine derivatives.
Brit. Appl. 30,924/47 (Texaco Dev. Corp.)—Barium soap grease.
Brit. Appl. 30,895/47 (Univ. Oil Prods.)—Hydrocarbon monomers.
Brit. Appl. 10,141/47 (Calif. Res. Corp.)—Aliphatic olefins.
Brit. Appl. 13,005/47 (Max B. Miller & Co.)—Cracking.
Brit. Appl. 12,640/47 (Shell Oil) — Combustion turbines.
Brit. Appl. 13,045/47 (Shell Oil) — Catalytic conversion.
Brit. Appl. 28,505-7/47 (Calif. Res. Corp.)—Alkoxy phenates.
Brit. Appl. 28,118/47 (Houdry Proc. Corp.)—Applying an atomized hydrocarbon mixture.
Brit. Appl. 28,373-4/47 (Shell Oil)—Lubricating compositions.
Brit. Appl. 28,545/47 (Shell Oil)—Synthetic lubricants.
Brit. Appl. 28,445/47 (Univ. Oil Prods.)—Aromatic hydrocarbons.

EYES ON TOMORROW..



...for the complex *flow control needs* of Modern Industry

Throughout more than a hundred years of making valves, The Wm. Powell Company has continually had its "eyes on tomorrow"—anticipating the future flow control requirements of industry.

This foresight was responsible for Powell's introduction of the first regrinding globe valve back in 1865. The design on which the patent was granted is shown above.

Again, more than twenty years ago, Powell had a vision of the miracles to come in the chemical and process industries. The Powell Special Design and Alloy Valve division was established and ever since, as the demands have multiplied for valves to handle ever higher pressures and temperatures and a consistantly increasing variety of corrosive media, Powell has always been ready with the valves to satisfy them.

Today there's a Powell Valve for every industrial flow control requirement and, as new demands arise, Powell will be ready to meet them.

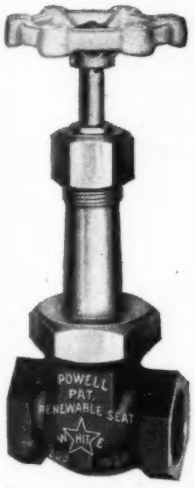


Fig. 1375—200-pound Bronze Gate Valve with screwed ends, inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel-bronze seat rings and disc.

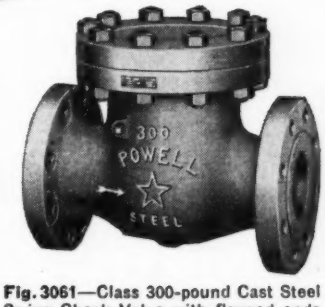


Fig. 3061—Class 300-pound Cast Steel Swing Check Valve with flanged ends and bolted flanged cap.

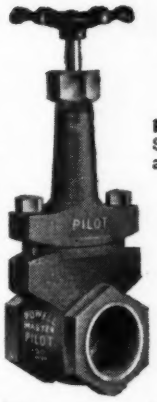


Fig. 1460—Iron Body Bronze Mounted "Master Pilot" Gate Valve, with screw ends, rising stem, bolted flanged bonnet and tapered solid wedge.

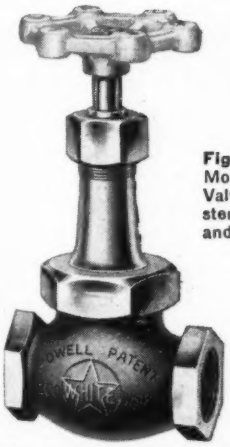


Fig. 1708—200-pound Bronze Globe Valve with screwed ends, union bonnet, renewable, specially heat treated stainless steel seat and regrindable, renewable, wear-resisting "Powellium" nickel-bronze disc.

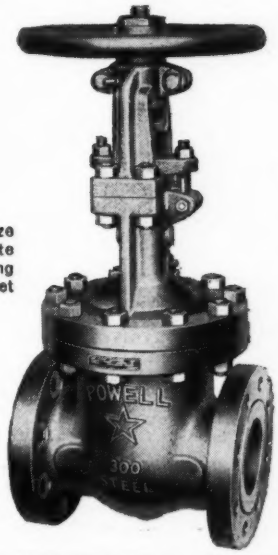


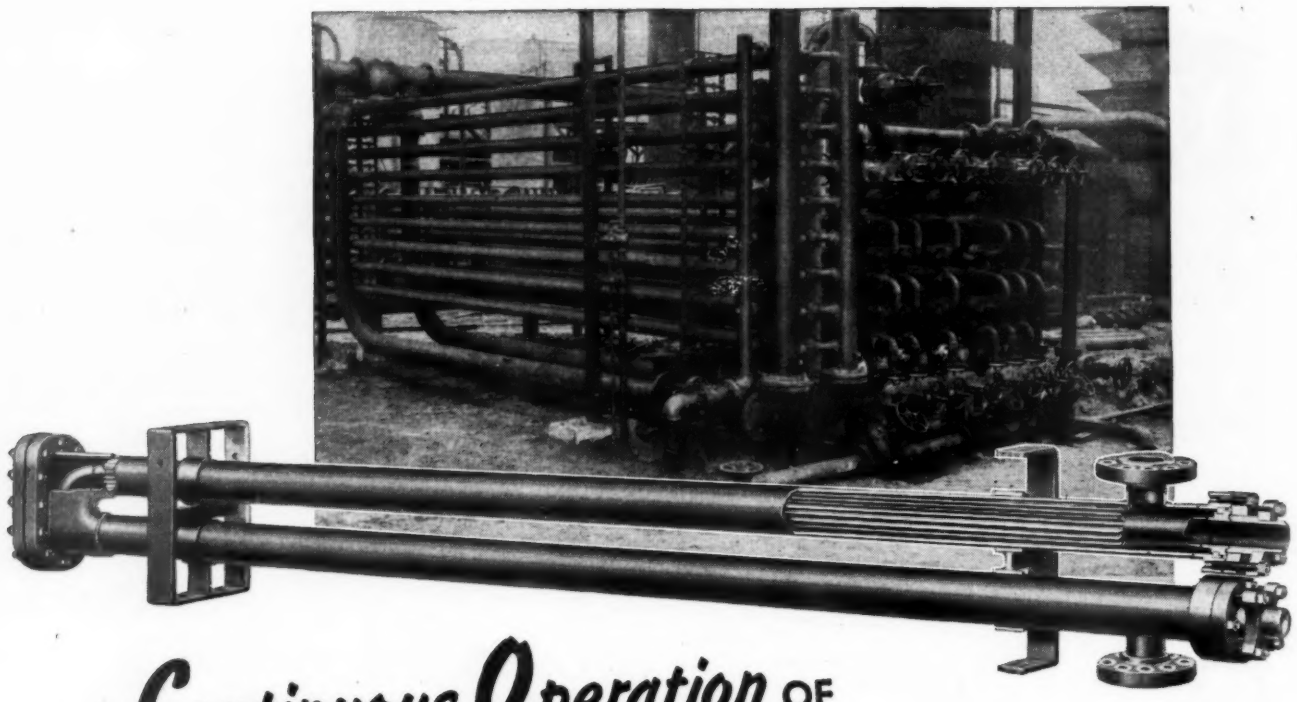
Fig. 3003—Class 300-pound Cast Steel Gate Valve with flanged ends, outside screw rising stem, bolted flanged yoke and tapered solid wedge.

The Wm. Powell Company

Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

POWELL VALVES



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without Shutdowns for Servicing

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HEAT EXCHANGERS

RESISTANCE WELDED INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT TRANSFER PRODUCTS

Efficient Operation and Fuel Saving Feature Four-step Oil Dehydrator

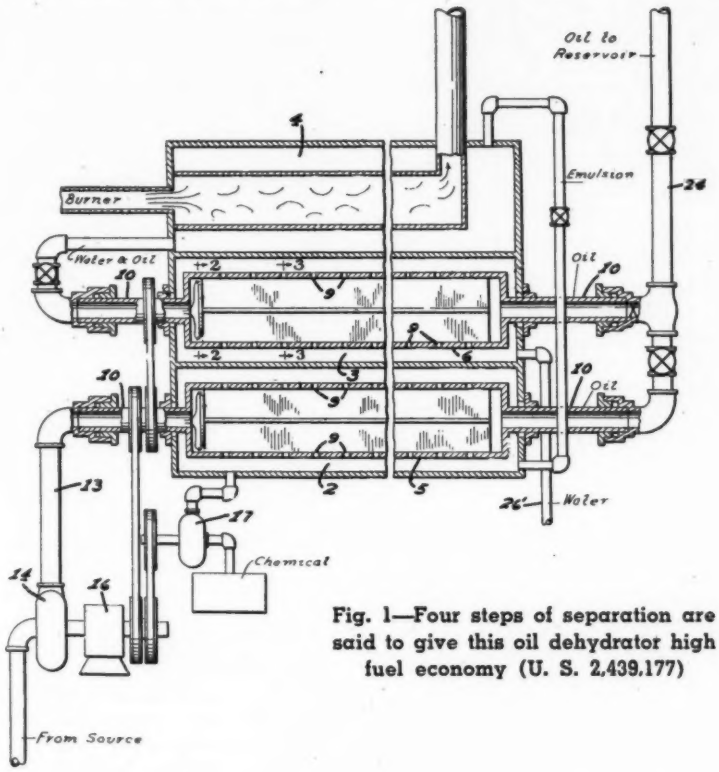

Fig. 1—Four steps of separation are said to give this oil dehydrator high fuel economy (U. S. 2,439,177)

MINIMUM USE OF fuel and of chemicals as well as conservation of all the oil is claimed for an oil dehydrator in which are incorporated a series of four operations.

The four steps described are: 1) preliminary centrifugal separation of oil and the water emulsion, 2) chemical treatment of the emulsion only, 3) heating the emulsion only, by which it is broken down into oil and water, and 4) centrifugal separation of the oil and water constituents of the emulsion.

One advantage cited over conventional methods of separation is that with a heat type dehydrator wasteful amounts of fuel must be used to heat all the oil so as to reach only a small percentage of emulsion in the oil. Another advantage is that with conventional centrifugal type separation, the discarded emulsion may contain as much as 40% oil.

The apparatus as shown in Fig. 1 consists of three fluid tight compartments 2, 3, and 4 in vertical tiered arrangement. Compartments 2 and 3 each contain a centrifugal drum 5 and 6, rotating horizontally. These drums have peripheral perforations 9 and are mounted on a tubular shaft 10. Recommended specifications for the drums are 12 ft. long by 6 ins. in diameter, and a speed of 3000 rpm.

In operation, motor 16 drives the intake pump 14, the chemical charging pump 17, and the centrifugal drums. Oil containing a water emulsion enters the dehydrator through line 13, passing into the first drum 5 where the emulsion is removed. The free oil (major portion) passes on to storage through line 24.

Treating chemical—water soluble salts such as sodium chloride or sulfate, or water soluble soaps such as sodium salts of fatty acids, or sulfonated fatty acids—is fed to the separated emulsion in compartment 2. The resultant mixture passes on to chamber 4 for heat treatment.

The broken down emulsion then passes into the second drum 6 for further centrifugal separation. Waste water discharges through line 26′ and the balance of the oil also leaves through outlet line 24.

U. S. 2,439,177, issued April 6, 1948, to Lester C. Manning, assignor to Ralph L. Senter, Oklahoma City.

Surface Combustion Is Employed In New Carbon Black Furnace

A SURFACE COMBUSTION furnace has been developed which is particularly applicable to manufacturing carbon black from gaseous petroleum hydrocarbons. It is said to improve on the conventional furnace process in that a pair of furnaces are not a requisite, all action taking place in a single unit. The product is stated to be superior for use in natural or synthetic rubber manufacture.

The cracking unit is shown in the drawing in Fig. 2, with its control mechanism shown in elevation and in smaller scale. It consists chiefly of tube 10, of a refractory material such as Carborundum. This tube is supported at its upper end in a packing arrangement in the outer metal housing 11. The lower end is arranged in an expansion joint to take care of the expected contraction and expansion. The middle part of the tube is porous, the ends are preferably impervious.

A combustible mixture of fuel gas and air is charged under pressure to the annular space 20 between tube 10 and housing 11. The feeding system includes pressure regulators on both lines, a proportioning meter 27, and a pressure regulator 31 on the combined inlet line 30. Sufficient pressure is maintained to force the combustible mixture through the porous walls of tube 10.

When the furnace is fired the mixture burns at the inner surface of the tube, which becomes incandescent. Actually, no flame as such appears within the tube. This is known as surface combustion. In a furnace of this type, temperatures as high as 3600° F. are developed.

Fluid hydrocarbon to be cracked is fed through pipe 34 into the lower end of tube 10, its flow being controlled by pressure regulators 35 and 36. The temperature to which the fluid is to be raised is controlled by differential pressure regulator 39 in the fuel mixture inlet line 30.

As the fluid passes upwardly

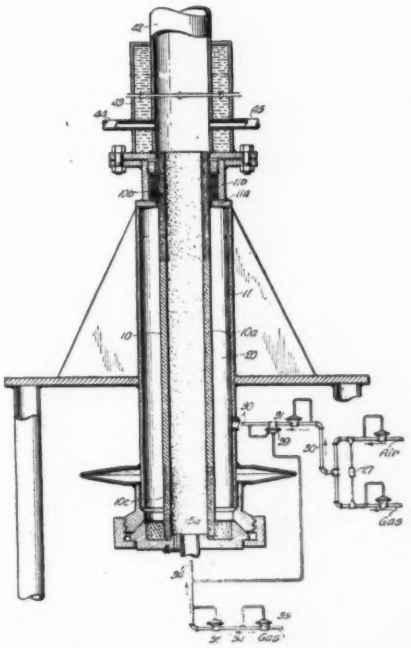

Fig. 2—Porous refractory tube 10 provides high temperature surface combustion in new carbon black furnace (U. S. 2,436,282)

through tube 10 it is cracked. The cracked fluid and products of combustion are cooled by water in jacket 43 and quenching fluids such as steam or water fed via lines 44 and 45 in stack 42.

Any suitable means may be provided for recovery of the cracked components. In making carbon black, the free carbon is preferably recovered by an electrostatic precipitator or filters connected at the discharge end of the furnace.

U. S. 2,436,282, issued Feb. 17, 1948, to Edwin O. Bennett, assignor to Continental Oil Co., Ponca City, Oklahoma.

Bubble Cap Assembly Stamped Inexpensively from Thin Alloy

SAVINGS IN WEIGHT estimated at as much as several tons in the case of large fractionators can be obtained by use of bubble cap assemblies fabricated inexpensively from thin sheet alloys, such as stainless steel or Monel metal, it is stated.

The reduction is not only direct in the case of the individual caps—and there may be as many as 5000 or more in a fractionator—but is also indirect in the case of trays, towers, and other supporting structures.

The assembly is shown in four views in Fig. 3. Riser 10 can be shaped from cylindrical stock. Its upper end is formed into a shape known as cruciform, and is perforated at four points 20 to provide for passage of vapor and liquid. The height of apertures 20 determines the liquid level in the tray.

The lower wall of riser 20 is pressed outwardly to form a flat flange 14, adapted to rest on the bubble tray 16. Hold-down spider 13, formed by stamping includes a nut-plate 23 welded at the bottom, thus eliminating the necessity for a separate, easily-lost nut.

U. S. 2,438,536, issued March 30, 1948, to Thomas W. Cairns, assignor to Solar Aircraft Co., San Diego, Calif.

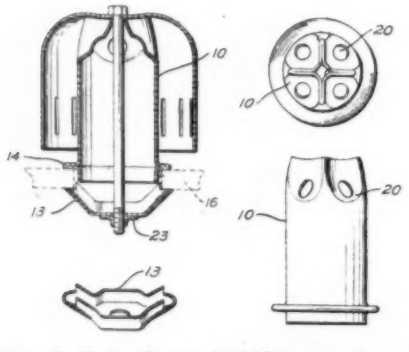

Fig. 3—Left above, bubble cap assembly. Left below, hold-down spider. Right above and below, riser formed from thin alloy tubing (U. S. 2,438,536)

Conventional Design Is Adapted To Metering Catalyst Flow Rate

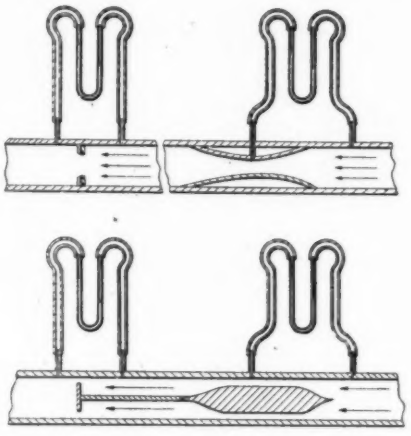

Fig. 4—Three modifications of a method for obtaining the flow rate of fluidized catalyst (U. S. 2,439,723)

FLOW RATES of pulverized catalyst or powdered coal through a line can be obtained by employing a U-tube manometer to measure the pressure differential caused by any conventional restriction in the line; for example, an orifice, a venturi section, or an elongated cylindrical core suspended on fine wires. The scheme treats the fluidized catalyst or coal particles as an ordinary fluid.

Three modifications of the patent are shown in Fig. 4, and all are relatively self-explanatory. In the case of the orifice plate, it is necessary to provide a rubber-like layer over its entire surface to prolong the life of the plate and to prevent a build-up of the solid particles carried by the gaseous medium around the orifice opening on the upstream side, which would affect the accuracy of the manometer reading.

U. S. 2,439,723, issued April 13, 1948, to Richard B. Engdahl, assignor by mesne assignments, to Bituminous Coal Research, Inc., Pittsburgh.

Other Recent Patents

Space does not permit the complete review of all patents issued recently on equipment for the petroleum processing industry. Following, however, are brief abstracts of those with greatest interest:

Thermal Cracking Unit designed specifically for manufacturing ethylene and the like, using a fluidized granular solid such as fused alumina; and also yielding substantial percentages of highly aromatic gasoline. U. S. 2,436,254, issued Feb. 17, 1948, to Sylvander C. Eastwood and Robert D. Drew, assignors to Socony-Vacuum Oil Co., Inc.

Lifter Roof designed with a counterweighting arrangement so that the weight of the roof remains constant. U. S. 2,436,348, issued Feb. 17, 1948, to John W. Allen, assignor to Chicago Bridge & Iron Co., Chicago, Ill.

Fume and Gas Ejector for removal of hazardous smoke fumes, and gases present in closed buildings and rooms during a fire; said to be particularly helpful to fire brigades in combating such emergencies more rapidly. U. S. 2,436,038, issued Feb. 17, 1948, to Roy B. Farrell, Buffalo, N. Y.

Moving Bed Catalytic Cracking Unit is said to provide improved flexibility with respect to control of space velocities by closer control of disengaging. U. S. 2,439,348, issued April 6, 1948, to Thomas P. Simpson, Russell Lee and Frederick E. Ray, assignors to Socony-Vacuum Oil Co., Inc.

Fluid Flow Regulator which is useful for maintaining gaseous flow at the constant pressures required in gas analyzing apparatus. U. S. 2,438,973, issued April 6, 1948, to Clarence Johnson, assignor to Bailey Meter Co., Cleveland, Ohio.

Tank Fabrication Method for rapid field assembly of metal vessels, tanks, and the like; involving temporarily erecting structure with bolts, and subsequent permanent installation by welding after removal of bolts. U. S. 2,439,266, issued April 6, 1948, to Samuel B. Settle, Parkersburg, W. Va., assignor to Casper A. Ruf, Parkersburg, W. Va.

Thermal Cracking to produce increased yield of aromatics and olefins, operating as high as 2000° F., and using fluidized technique with refractory, non-catalytic materials such as crushed coke, powdered coal, ground pumice, or sand. U. S. 2,436,160 issued February 17, 1948, to Forrest H. Blanding, assignor to Standard Oil Development Co.

How to Obtain Patents

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EQUIPMENT MATERIALS PROCESSES LITERATURE What's New!

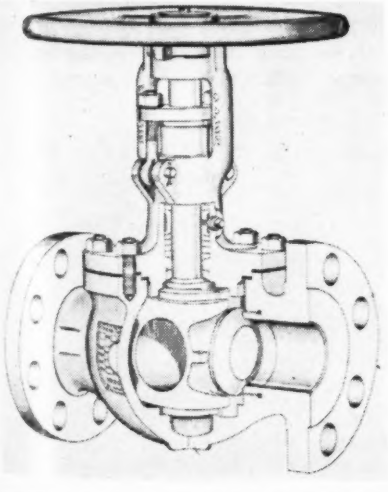
Reviewed by WILLIAM C. UHL, Equipment Editor

1—Pressure Transmitter

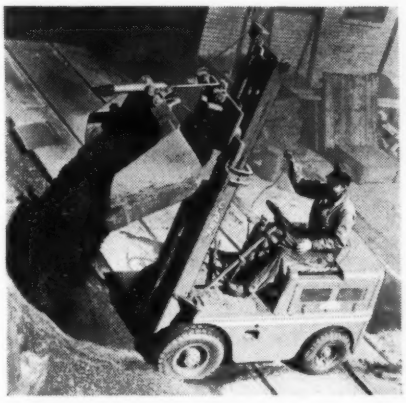
Easier installation and maintenance is claimed through a change in design of the Republic Differential Vapor Pressure Transmitter as worked out in collaboration with Universal Oil Products Co. for use on narrow boiling range fractionating columns. In the new design, the reference fluid is contained in a bulb system similar to that employed in the ordinary vapor pressure thermometer. The bulb, which is fitted with a standard 1¼ in. IPS bushing, is mounted in the column and transmits the reference fluid vapor pressure to the measuring bellows through a sealed tube system. The column vapor pressure is imposed on the other side of the measuring bellows through a separate pressure connection. Republic Flow Meters Co.

2—Plug Valve

A new plug valve, said to be finding increased applications in refineries and natural gasoline plants, is the Reed "Twin-Seal" Valve, shown for the first time at the International Petroleum Exposition in Tulsa, May 15-22. It employs two "floating" discs which are set firmly in tight seal connection with the seating ring by a wedge design in the plug when the valve is in the closed position. Correspondingly, the discs are readily loosened with no galling or sticking when the valve wheel is turned to the open position. Valves are available presently in sizes up to six in., in cast steel body, for 150 SWP, 230 WOG, and 300 SWP, 500 WOG. Reed Roller Bit Co.



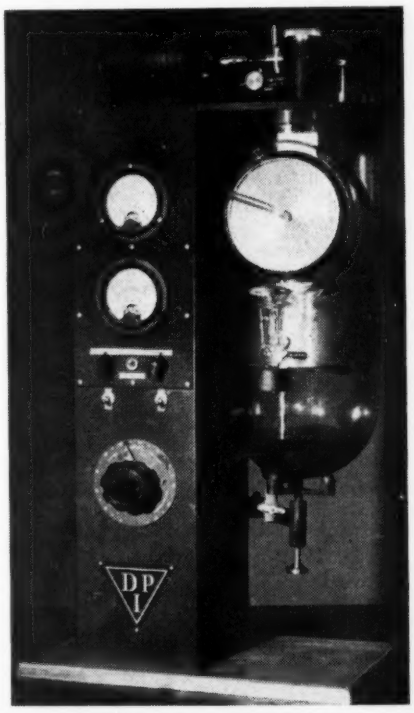
3—Shovel Truck



Useful for jobs in confined areas, a new fork truck shovel attachment includes a pneumatic snubber which is designed to minimize the shock and strain to the upright assembly when the load is discharged. The shovel has three-point suspension, with a roller cam lock and single point hook, which permits release of the load with a 15-lb. pull. Built of ¼-in. steel plate, with a blade 6 in. wide, of hardened steel, and flame hardened edge. It is interchangeable with forks and other attachments mounted directly to the standard fork bars on Clark fork trucks. Clark Equipment Co., Tructractor Division.

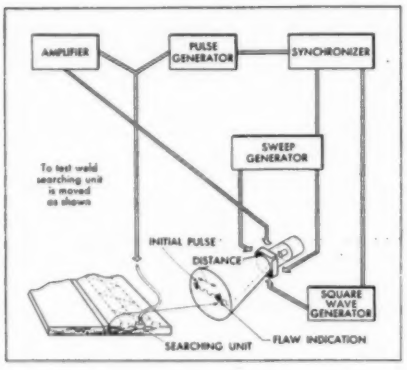
4—Molecular Still

The new model, Type CMS-5, laboratory molecular still, now ready for delivery this month, provides for the first time a laboratory size unit for molecular distillation of fats, oils, and waxes. It employs a centrifugal evaporator embodying the same principles as the larger commercial stills, and consisting of a conical rotor 5 in. in diameter, warmed by an embedded heater. The condenser is formed by a flattened surface of the bell-jar which encloses the complete unit. Material to be processed is fed by a small pump onto the center of the rotor, where it spreads by centrifugal action in a thin, uniform layer across the surface. Distilland is in contact with the evaporator for 0.2 to 0.5 secs. Normal operating pressure is 0.1 to 10 microns. Samples of two liters or less may be handled. The still occupies about 3 sq. ft. of bench space, exclusive of the mechanical pump, which occupies an equivalent area, and is 32 in. high. Meters and controls are mounted on a single panel and include a thermocouple dial, Pirani type vacuum gage, and a variac to control evaporator temperature. Distillation Products, Inc.



More "What's New!" Items, page 602

5—Tests Welds by Sound

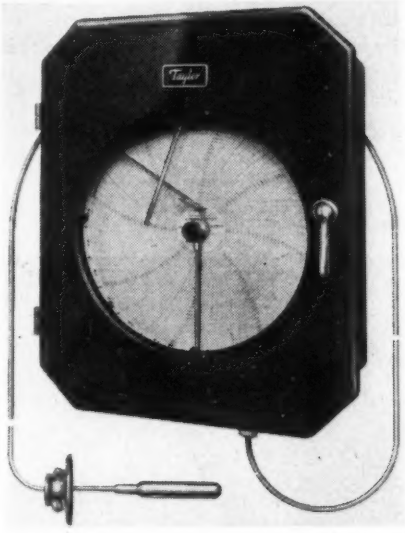


High frequency sound waves are employed by the "Supersonic Reflectoscope" in testing welds in ferrous metals and light metals for lack of bond, inclusions, or voids. The searching unit, whose primary element is a quartz crystal, is placed on the smooth parent metal adjacent to the weld, or even at some distance from it. A sound beam travels by successive reflections between the surfaces of the material until an interface is reached. Weld metal itself does not constitute a reflecting interface, but any voids or inclusions will reflect part of the waves back to the searching unit, where it will be amplified to indicate a vertical deflection on the horizontal trace on an oscilloscope screen. A time marking system allows accurate calibration to determine the distance from the searching unit to the flaw. The instrument is said to make possible location of smaller defects at greater depths than with the X-ray or other non-destructive testing equipment. Sperry Products, Inc.

6—Handles Three Drums

Developed as an attachment for another attachment, the Hyster Drum Handling Arms were designed for transporting one, two, or three 50 gal. oil drums. They followed the previous design of "Load - Grab" method for palletless materials handling. The Drum Handling Arms are metal tines with rounded, hollow sides, measuring 16½ in. in length by 8 in. in width, and spread from a minimum 17 to a maximum 62-in. Handling capacity is 1780 lb. The device is available for the Hyster Model "20", a gasoline engine-powered fork lift truck, which will lift its load to a height, to the underside of the load, of 9 ft. Hyster Co.

7—For Sub-zero Work



The single capillary, organic liquid-actuated Taylor Thermal System is said to be particularly applicable to use where a small bulb is required, short range intervals are desirable, the manufacturing process is sensitive to mercury, and sub-zero temperatures are encountered. It utilizes a single bore capillary and single Bourdon spring with a U-shaped bimetallic compensator on the spring for case temperature changes. Taylor Instrument Cos.

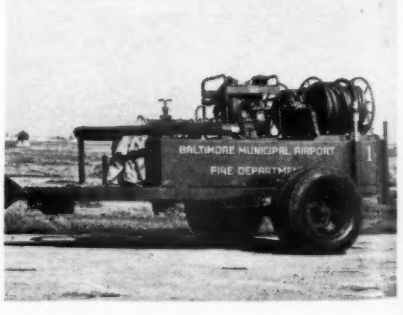
8—Plastic Packing

The new "Chemlon" line of packing material for valves, centrifugal and rotary pump shafts, reciprocating rods and other similar services is made from E. I. Du Pont's "Teflon", the chemically-resistant, flexible plastic, tetrafluorethylene. The material is non-adhesive and unaffected by any solvent acid mixtures, acids, or caustic solutions at temperatures up to 690° F. Chemlon is furnished in round cross-section braided spool-form, in sizes ⅛ to 1-in. on spools, and in two styles—706 for service up

to 300° F., and 704 for service above 300° F. It is also also supplied in ring form in two styles—772 containing no lubricant, and 776 impregnated with graphite. Crane Packing Co.

9—Oil Fire Fighter

Designed and equipped for use at airports and in petroleum refineries, a new fire fighting trailer is said to produce 2500 gals. of fire-smothering foam in less than two minutes. Pulled by a jeep or a pickup truck, the trailer has a two-compartment tank carrying 250 gals. of water and 25 gals. of "Aer-o-foam" liquid. Equipment includes two all-purpose foam nozzles; 50 gals. of "Aer-o-foam" liquid, including the 25 gals. in the tank; one CO_2 extinguisher; two reels for carrying 100 ft. of one-inch booster hose; and a 100-psi. pump with a foam proportioner; Dual wheels of pressed steel mount 6.50 x 16, 6 ply tires—four supplied. Trailer frame is of steel, welded construction. Axle capacity is 5000 lbs. Trailer has connection cable and safety switch for hooking onto jeep or truck. Breakaway and safety chains are provided. Delivery can be made in 60 days, manufacturer states. National Foam System, Inc.



More "What's New!" Items, page 604

National's Overhead Foam Spray Deflector shows its effectiveness in an outdoor demonstration.

Quickly, the Overhead Deflector spreads Aer-O-Foam over the fire, completely smothering the blaze.

FIGHT IT WITH NATIONAL

AER-O-FOAM

ACTS QUICK . . . PREVENTS FLASHBACKS . . . STOPS LOSS

Day or night . . . in refineries, bulk plants or warehouses, when fire strikes it means loss of material . . . valuable irreplaceable equipment . . . *and production.* Proved fire protection equipment is your safest continuous production and delivery insurance today.

Protect your plants with National Aer-O-Foam's equipment which includes "industry-proved" Overhead Spray Deflectors—as illustrated in operation. These are easily installed over those points requiring fire protection . . . spray directly on the fire. Help prevent serious losses before they happen.

National Aer-O-Foam forms a thick, tough, long-lasting airtight blanket of foam that snuffs out flames . . . insulates threatened areas and prevents flashbacks. At the same time, Aer-O-Foam is non-corrosive—is easily washed away with hose stream, or after drying can be readily brushed off machinery, walls and floors.

National Foam manufactures chemical as well as mechanical foam and the equipment for applying them . . . and offers you the technical assistance to engineer fire protection.

NATIONAL FOAM SYSTEM, INC.

Headquarters for Foam Fire Protection

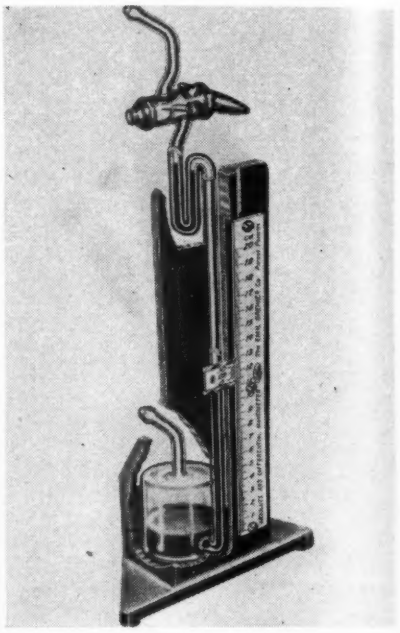
Packard Building. Philadelphia 2. Pa.

10—High-pressure Level Gage

The Jerguson High Pressure Gage, Type T-50, is designed to measure liquid levels at pressures of 10,000 psi. or higher, depending upon safety factor requirements. Manufacturer said the gage has been tested up to 20,000 psi. Chamber and covers are machined from bar steel stock, and the port glass is 11/16 in. thick, tempered Pyrex. The gage is built in standard lengths up to approximately 6 ft. It is also available in stainless steel or other special metals to resist corrosive conditions. Jerguson Gage & Valve Co.

11—Easy to Clean

A new type manometer is said to reduce the task of cleaning and filling a closed end manometer to a relatively simple process of cleaning and filling an open-end U-tube. A single reading is required to obtain precise measurement automatically



corrected for ambient temperature and reduced to a height of mercury at 0° C. The closed end is effected by means of a U-tube which traps mercury to form the vacuum seal, and an oblique bore stopcock above the trap to hold up the mercury seal. For differential readings the stopcock is kept open and connected to the lower source of pressure. The glass portion and the vinylite scale are mounted on an aluminum stand. Range of the instrument is 0 to 200 mm., vernier reading to 0.1 mm. Supplied without mercury. Emil Greiner Co.

Trade Literature

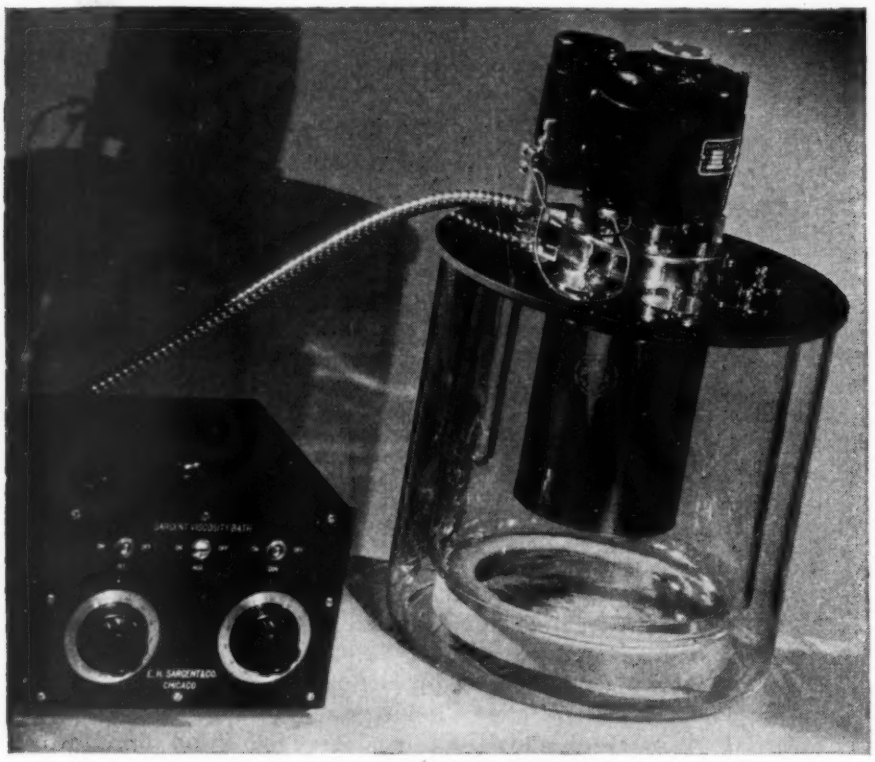
12—Materials Guide

Materials of Construction for Flowrator Instruments, Catalog Sect. 97, a four-page engineering bulletin giving recommendations on construction materials for almost 400 corrosive liquids and gases; includes end fittings, metering floats, and packing for stuffing boxes. Fischer & Porter Co.

13—Measures Flow & Level

The D/P Differential Pressure Cell, Bulletin 420, describes a new pneumatic force balance device for accurate measurement and transmission of flow and liquid level. Range is 100 to 800 in.; max. working pressure, 500 and 1500 psi. The instrument was shown for the first time at the International Petroleum Exposition in Tulsa, May 15-22. Foxboro Co.

More "What's New!" Items, page 606



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For Kinematic Viscosity Measurements

Any selected operating temperature is uniformly maintained within ±0.02° F throughout the entire working area of the Sargent Viscosimeter Bath. This bath as illustrated and as listed under catalog No. S-83255 provides a temperature range from 0° F when adequately cooled to 210° F. This range can be extended to 342° F by addition of one 250 watt auxiliary heater.

An inner glass jar contains the bath medium and an outer glass jar creates an air jacket to prevent excessive heat loss when operating at high temperatures. The bath cover has individual positions for six pipettes of Ostwald, Fenske-Cannon or Ubbelohde types which can be observed through the transparent walls of the bath while immersed thus permitting readings to be made without removing pipettes from the bath.

Inside diameter, 10 inches; inside depth, 10 inches; outside diameter, 12 inches; maximum power consumption, 1000 watts. For operation from 115 volt, 60 cycle, single phase circuits.

S-83255 SARGENT VISCOSIMETER BATH—Oil, Constant Temperature, High Precision, 0.02°. (Patent No. 2,037,993).....**$230.00**

S-40835 HEATERS—Immersion, Electric, 250 watt. For use as auxiliary heater for extending temperature range to 342° F.....**$9.00**

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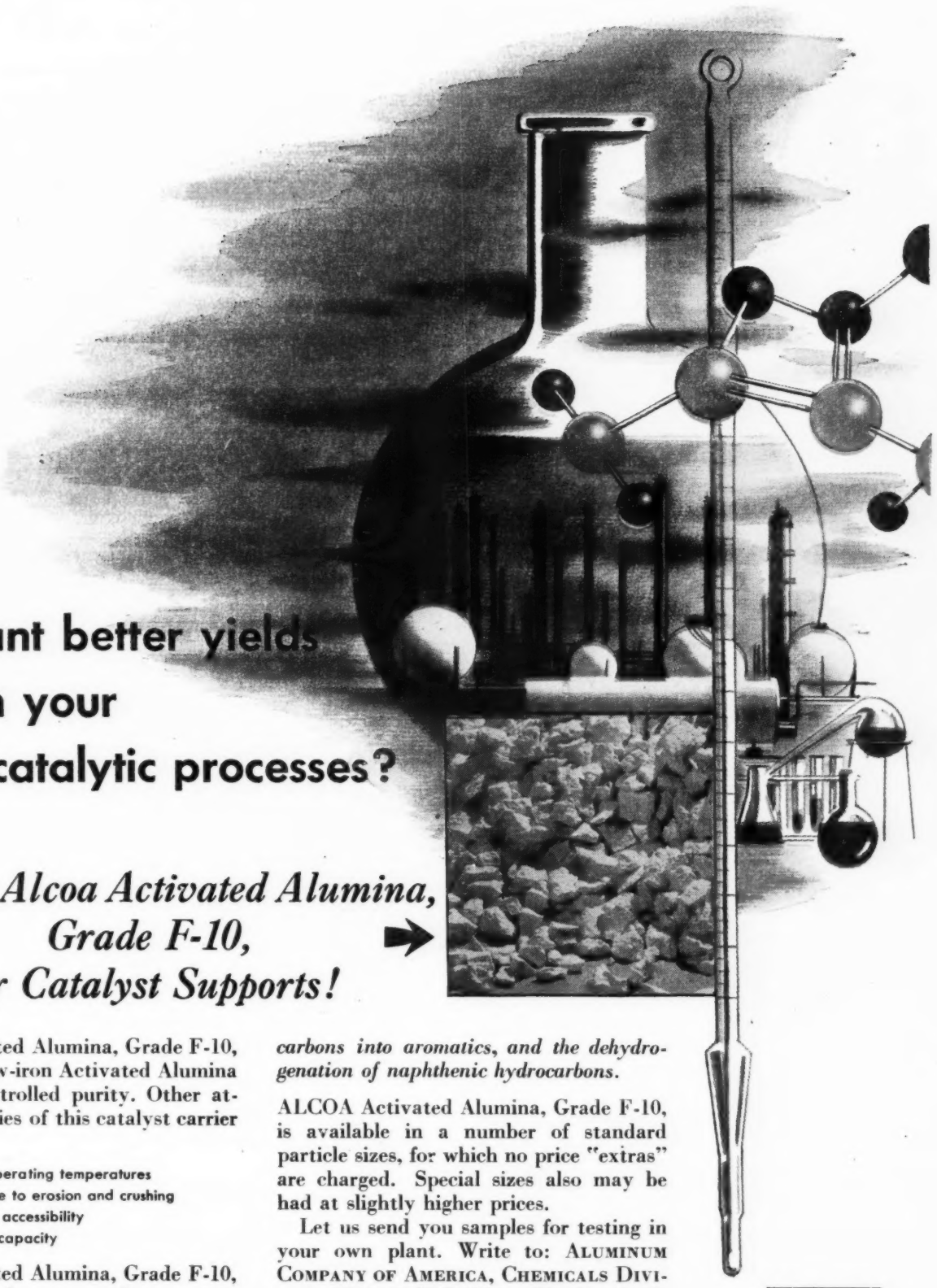

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ALCOA Activated Alumina, Grade F-10, is used extensively as a catalyst support for such conversions as: *Aliphatic hydrocarbons into aromatics, and the dehydrogenation of naphthenic hydrocarbons.*

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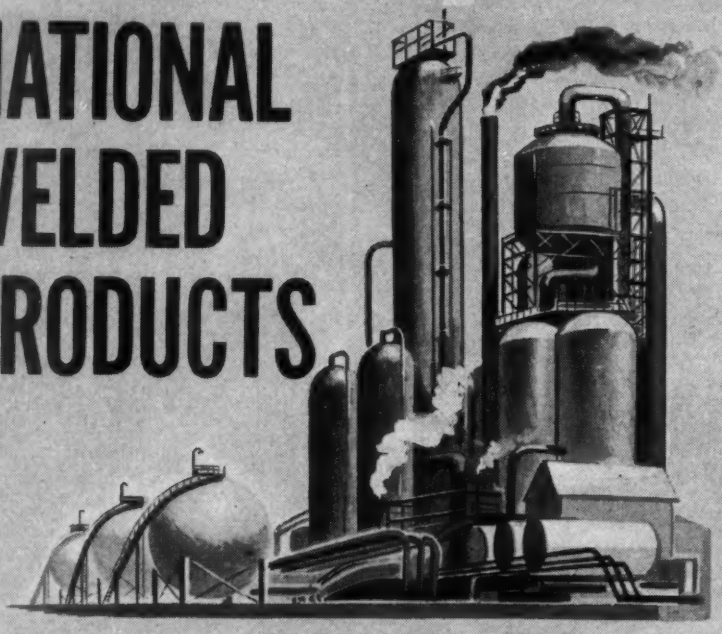

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FROM OPEN HEARTH, STAINLESS, ALLOY AND CLAD STEELS

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8' 8" x 18' 4⅝" long.
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Dependability is the by-word for National Welded Products. It is built into every phase of engineering and production—to assure you of pressure vessels and other fabricated equipment that meets exacting codes and requirements. Let us work with you in solving your difficult fabricating problems.

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What's New!

14—Multi-stage Pumps

Pacific Precision-Built Multi-Stage Centrifugal Pumps, Types OV, A, and AC, Bulletin 104, illustrated; describes pumps from 2 to 8-in. sizes, for up to 850°F. and 2000 psi. service, at up to 2700 gpm. Pacific Pumps, Inc.

15—Level Control Relay

Leveltronic Relay, Catalog No. 27, gives details and prices on the new Leveltronic Relay for control of liquid level, interface, pressure and temperature. R-S Products Co.

16—Hypersorption Process

Hypersorption, Bulletin No. 0-48-3; 8-pg. illustrated booklet describing the new Hypersorption process for separation of gases by adsorption on activated carbon; gives such applications for its use as hydrocarbon syntheses, hydrogen purification, ethylene recovery, acetylene recovery, chlorination processes, and ammonia synthesis. Foster Wheeler Corp.

17—Grease Mobilometer

The S. I. L. Mobilometer, a four-page bulletin describing an inspection instrument for products ranging from heavy grease to light, soap-thickened oils, and developed by the laboratories of Esso Standard Oil Co. Koehler Instrument Co.

18—Refining Processes

Petroleum Refining Processes, 24 pages illustrated with photographs and simplified flow diagrams describing various processes licensed by UOP. Universal Oil Products Co.

19—Industrial Chemicals

Hercules Products, Form 698, classifies approximately 100 chemicals by family groups, describing each briefly as to chemical makeup, uses, and potential applications. Hercules Powder Co.

20—Chemicals & Catalysts

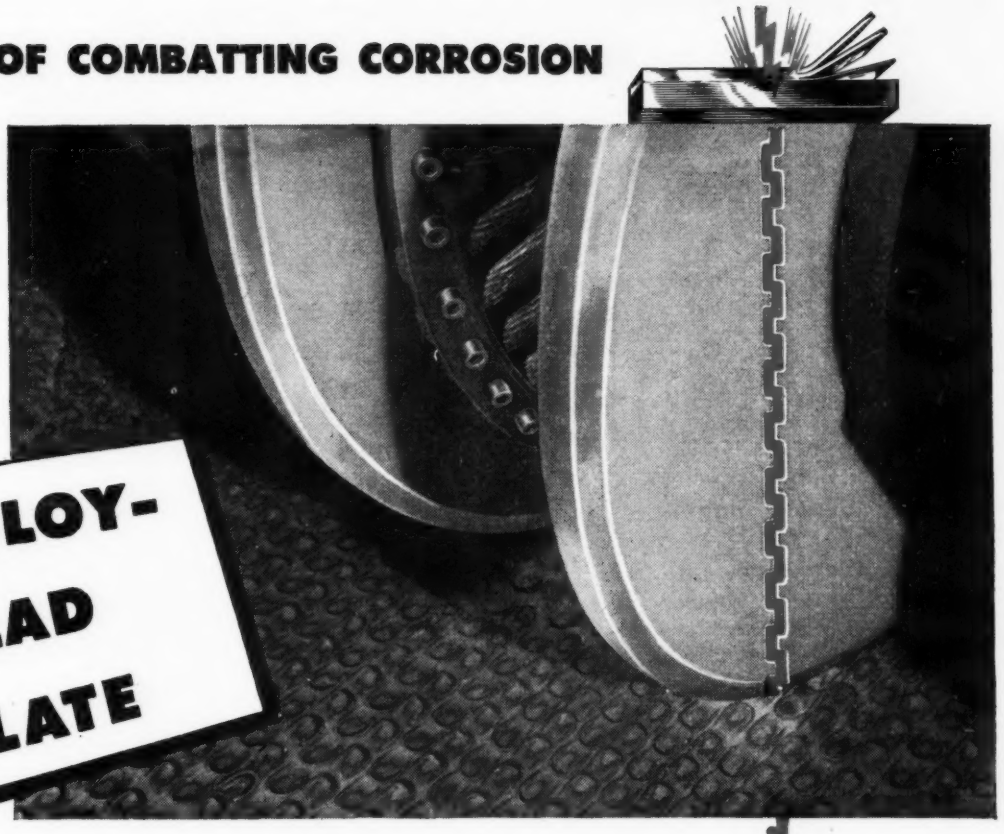
Industrial Chemicals, a 32-page booklet describing a line of chemicals including fluorides and catalysts. Harshaw Chemical Co.

21—Ion Exchange Materials

Nalco Ion Exchange Materials Booklet, presents discussion of the principles of ion exchange, technical data on types of ion exchange materials sold and serviced by Nalco, and suggested applications. National Aluminate Corp.

More "What's New!" Items, page 608

CUTS THE COST OF COMBATTING CORROSION



CROLOY-CLAD PLATE

COMBINES 9 MONEY-SAVING ADVANTAGES

The advantages listed at the right explain why B&W Croloy-Clad Plate has gained wide acceptance for fabricating process equipment requiring corrosion-, heat-, and oxidation-resistance surfaces; and protection against product contamination. It has proved to be the most economical solution to many diversified problems in refineries and chemical plants, calling for protection against destructive conditions.

Croloy-Clad Plate is produced by an exclusive B&W process which bonds a corrosion-resistant alloy cladding to a base metal. Newest machine for producing Croloy-Clad Plate is partially shown above. It represents an important advance in the art of seam-welding "clad" steels for fabrication into cost-saving process equipment.

Send for new booklet describing this versatile economical material.

- Alloy cladding is bonded to base metal with resistance welds.
- Bond offers high resistance to failure due to repeated heating and cooling.
- Corrosion-resistant lining of known thickness is provided over full surface area.
- Layer construction of cladding permits variation in thickness for specific requirements.
- Full corrosion resistance of lining retained by heat treatment.
- No interface carbon migration occurs between base metal and Croloy lining.
- High strength of bond permits the welding of trays, supports, and other internal fittings directly to the Croloy lining.
- Croloy-Clad Plate fabricates as easily as plain steels, and without special precautions.
- You pay no premium for the advantages of Croloy-Clad Plate.

S-84

PROCESS EQUIPMENT — Alloy, Clad, and Bonded Pressure Vessels . . . Heat and Abrasive-resistant Alloy Castings . . . Special Process Equipment.

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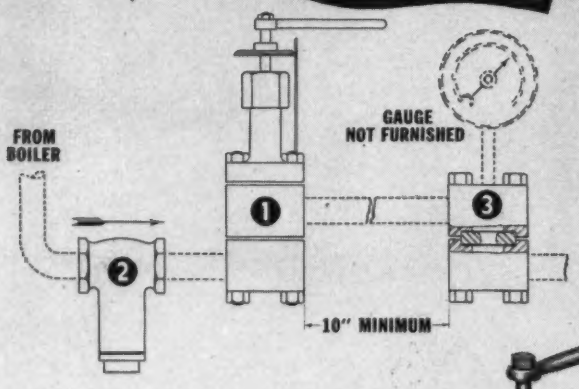
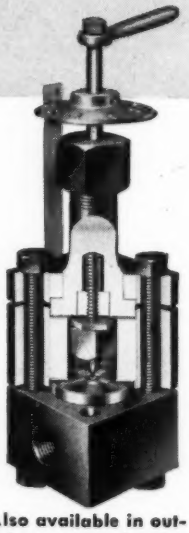
Custom-Built... CONTINUOUS BLOWDOWN



STRONG Dual-Orifice Assembly gives Greater Accuracy . . . Rugged Service!

Strong's Continuous Boiler Blowdown Assembly includes a Strong *block steel* Evrtyte* Valve (1), a strainer (2) and an orifice block (3). *custom-built* and accurately sized for *your own job conditions.*

The assembly is essentially two orifices arranged in series. The first orifice (valve) is variable . . . . the second is fixed. Correct proportioning of orifices provides extremely accurate control and reduces wire drawing.



Also available in outside screw and yoke.

Strong Evrtyte steel valves have special Anum-Metl X† seats and discs of 750 Brinell surface hardness for long life. Available for pressures to 1500 psi and temperatures to 800° F. or 6000 psi non-shock cold service.

Let us custom-size your continuous blowdown system. Send for Catalog No. 102 and our Continuous Blowdown Check-Chart today!

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Reducing Valve | No. 80 Series Trap | Strainer

STRONG

What's New!

22—Radioactivity Assays

Tracerlog, No. 10, April, 1948, describes the new SC-6 Automatic Sample Changer for expediting routine radioassays automatically on as many as 25 samples. Tracerlab, Inc.

23—Ball-type Plug Valve

Kerosphere, Bulletin K-48, gives details on the new "Kerosphere" nonlubricated "Ball" valve for high and medium pressure service in oil refining, petro-chemical processing, and related services. Ball-type design is said to eliminate galling, abrasion, and sticking. Kerotest Mfg. Co.

24—Alloy Castings Guide

Buyers' Guide for Ni-Hard Castings, 1948 Ed., 1st revision; 8 pgs. on the facilities, specialties, and locations of authorized producers of Ni-Hard, a nickel-chromium white alloy cast iron, the hardest commercial product of the iron foundry and useful for severe abrasion services. International Nickel Co., Inc.

25—Tube Fittings

Flodar Tube Fittings, Catalog 400; 12-pg. booklet giving specifications and describing two new fittings for high fluid pressure service, 0 to 7500 psi. on 1/4-in. O.D. tubing, and 0 to 3500 psi. on 1-1/2-in. O.D. tubing. Fittings are of both flare and no-flare type. Flodar Corp.

26—Combustion Safety

Flame-otrol Combustion Safeguard, Bulletin F1-1; illustrations, wiring diagrams, and description of new combustion safeguard for oil fired furnaces, ovens, boilers, and so on. Wheelco Instruments Co.

27—Metal Lab Vessels

Containers and Flasks for Liquefied Gases; 4-pg. bulletin describing a line of copper and stainless steel flasks for liquid oxygen, nitrogen, hydrogen, and helium; and stainless steel Dewar flasks useful in jet-propulsion fuel research. Hofman Laboratories, Inc.

28—Cooling Units

Young "VAD" Cooling and Condensing Units, Catalog No. 448, describes a new line of vertical air discharge cooling units for cooling of water, oil, and gas, as well as steam and vapor condensing in any combination, in sizes capable of dissipating from 3 to 15 million Btu/hr. under standard conditions. Young Radiator Co.

What's New!

29—Oil Specialties

Eureka Formulated Oils, a new brochure containing technical data on a line of graphited cutting oils, spindle oils, and conveyor lubricants and greases. Welding Equipment and Supply Co.

30—Welding Methods

Tempil Topics, Vol. 3, No. 4, April 15, 1948, issue discusses the subject of welding of dissimilar metals, suggesting methods and electrodes. Tempil Corp.

31—Air Safety Valve

Danielson Two-Way Automatic Safety Check; Folder describing a new check valve said to eliminate dangerous whipping action in air lines. Available in ¾-in. size. Danielson Safety Valves, Inc.

32—Dew-point Recorder

The "Surface" Dew-Point Recorder and Atmosphere Selector, Bulletin SC-137. 4-pg. folder presenting details on a new automatic recorder for dew point in gases; illustrated with installation photographs, a schematic operational chart, and a graph of dew point vs. percent water vapor by volume. Surface Combustion Corp.

33—Painting Guide

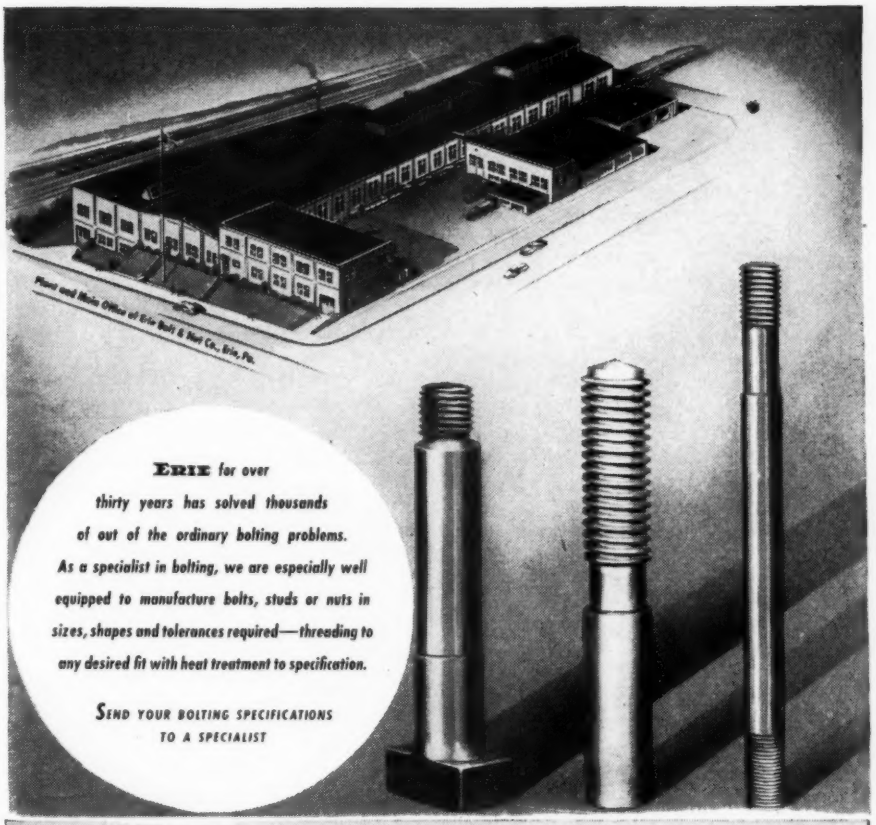
Timely Topics, No. 14, a folder on maintenance paints for petroleum refineries includes a reference guide for the selection of the proper coating for various types of refinery equipment, including towers, pumps, tanks, condensers, furnaces, piping, and stills. L. Sonneborn Sons, Inc.

34—Instrumentation

Instrumentation, Vol. 3, No. 2, includes an article on the use of instruments for the control of a vapor recovery unit at the El Dorado refinery of the Skelly Oil Co. Brown Instrument Co.

For Your Convenience

Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing page 601. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.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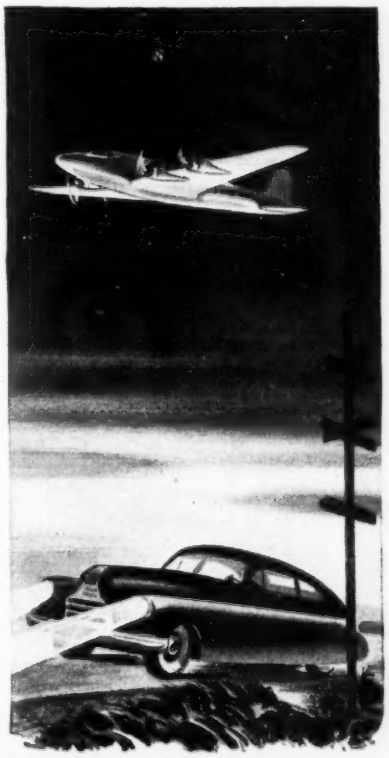
Metasap Stearate Bases increase the stamina of your lubricants—help them keep pace with the increased power and speed of today's cars and planes. In fact, Metasap Bases improve the performance of your lubricants in *all* modern high speed machinery.

Metasap Bases make lubricants crystal-clear, insoluble, anhydrous . . . lubricants that will not separate, bleed, cake, freeze, evaporate or dissolve . . . that will perform efficiently under *all* conditions. *Other advantages . . . less* base and *more* mineral oil—the true lubricating ingredient. Metasap offers you a wide range of stearates to produce in your greases any desired consistency. Write today for technical details.



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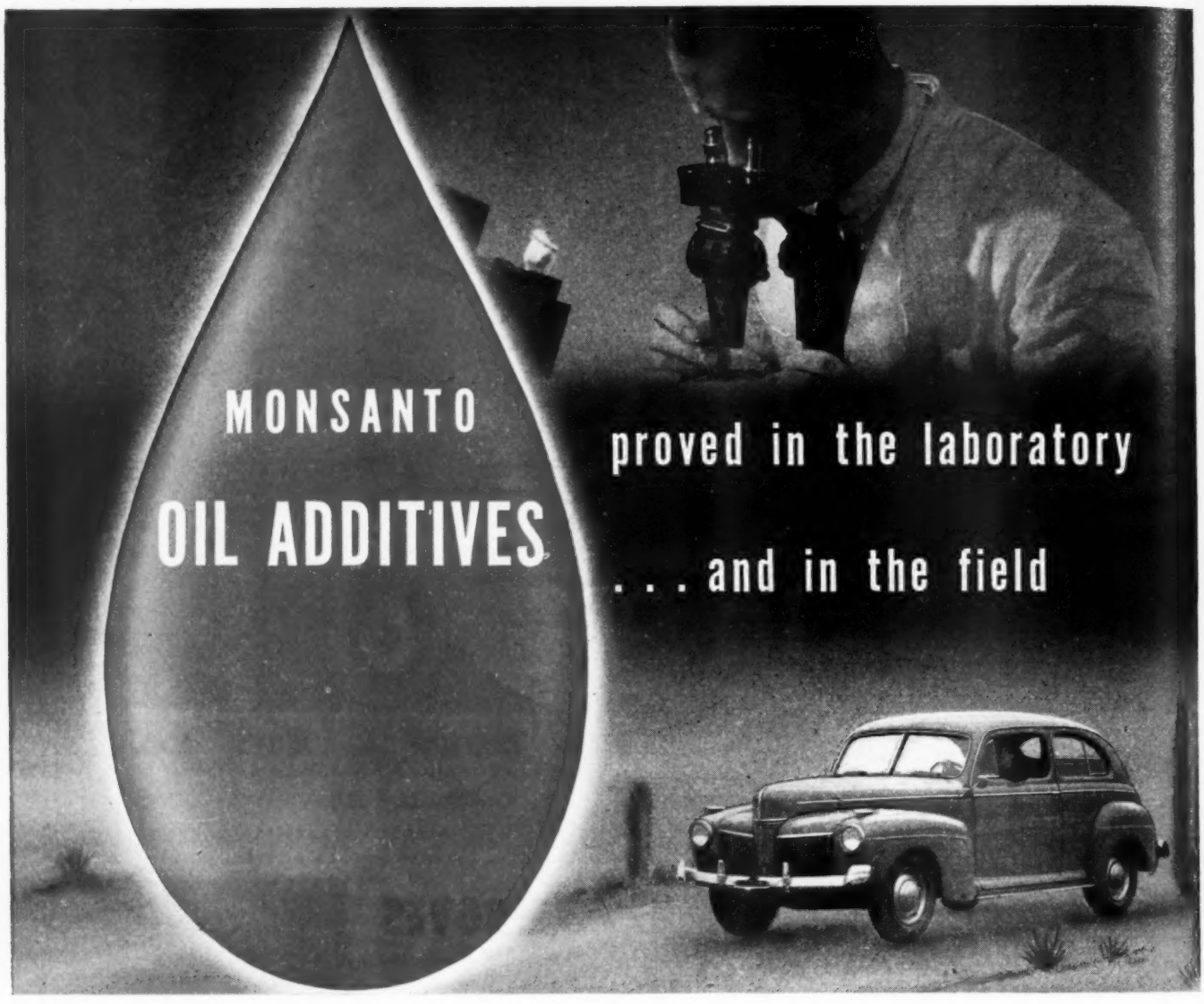
Stearates
of Calcium · Aluminum · Lead · Magnesium · Zinc



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SANTOPOUR,* SANTOPOUR B — Designed to maintain lubricant fluidity at low temperatures.

GEAR LUBRICANT ADDITIVES

SANTOPOID* 29—Provides in a single gear lubricant the performance characteristics necessary for properly lubricating hypoid and other gears under the severe operating conditions of high speed passenger cars, heavy-duty trucks, tractor-trailers and buses.

MOTOR OIL INHIBITORS

SANTOLUBE* 395, 398 — Furnish optimum protection against bearing corrosion and oil oxidation. Recommended primarily for "premium" motor oils.

SANTOLUBE 394-C — Used in connection with any selected level of detergency to insure oil stability and bearing corrosion protection.

MOTOR OIL DETERGENTS

SANTOLUBE 203-A, 222, 520—Detergent and dispersant type additives that minimize ring sticking by dispersing lacquer, sludge and other insoluble oil contaminants.

MEDIUM AND HEAVY DUTY COMBINATIONS

Special preblends of a straight detergent and a straight inhibitor (Santolube 394-C) are recommended for medium and heavy duty service.

VISCOSITY INDEX IMPROVERS

SANTODEX — Monsanto's new viscosity index improver. When added to suitable base stocks, makes possible easier starting in cold weather, lower oil consumption at high temperatures, better oil-film protection for engine working parts.

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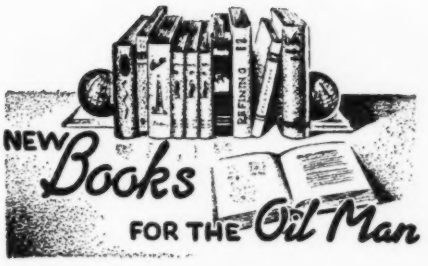

Copies of all books reviewed here may be ordered from the Reader's Service Department, Petroleum Processing, 1213 West Third St., Cleveland 13, for the price listed, postpaid, unless indicated otherwise. Ohio purchasers please add 3% tax. U. S. Government publications should be ordered direct from the Superintendent of Documents, Washington, D. C.

Practical Engine Test Manual Published by Testing Society

ASTM Manual of Engine Test Methods for Rating Fuels, American Society for Testing Materials Division on Combustion Characteristics; 6 x 9 in., 320 pages, illustrated, stiff cloth binding, $8.00 (March, 1948).

The new *ASTM Manual of Engine Test Methods for Rating Fuels,* just off the press, covers in a concise form the five methods that are now commonly used by the petroleum and automotive industries — Motor, D 357; Research, D 908; Aviation, D 614; Supercharge, D 909; and Cetane, D 613. In addition, six supplements cover thoroughly the design of laboratory facilities and equipment, the availability and supply of materials and apparatus, and the operation and maintenance of equipment.

Excellently illustrated with photographs, the information is presented in a way that will help laboratory supervisors and executives build and equip modern engine testing laboratories. It is designed primarily for the operators of test engines and the mechanics who inspect and maintain the test engines. The Manual is arranged so that those things which are used most frequently are in the front of the book.

It was prepared under the auspices of the Division on Combustion Characteristics, following its organization in March, 1947, by ASTM Committee D-2 on Petroleum Products and Lubricants. Members of the Editorial Section assisted in the preparation and editing of the manual.

Fuel Technology is Covered In New British Publication

The Elements of Fuel Technology, by Godfrey W. Himus, 6 x 9¾ in., 506 pages, illustrated, indexed, stiff cloth binding. Order direct from publisher: Leonard Hill Ltd., 17 Stratford Place W.1, London, England.

This newly published treatise on the elements of fuel technology gives surprisingly thorough coverage of a field one would expect should require at least three times the space. It is indeed unfortunate that much of the material is already old, and that so much of present developments in this science could not be included.

The reason for this is that wartime restrictions and circumstances prevented its publication until late in 1947, although the manuscript was completed during 1943, some four and a half years earlier.

The major portion of the volume deals with solid fuels. However, three chapters are of some interest to the oil man—1) on coal as a source of liquid fuels, describing the Bergius and the Fischer-Tropsch processes, 2) on liquid fuels, discussing crude petroleum, shale oils, etc., and 3) on fuel oil and its composition, dealing with the combustion of liquid fuels in internal combustion engines.

The author, Dr. Himus, is presently assistant professor in fuel technology at the Imperial College of Science and Technology in London. He was formerly chief chemist to the Municipal Electricity Department in Shanghai.

Readers who wish to obtain a copy of *Elements of Fuel Technology* should order direct from the publisher, Leonard Hill Ltd., 17 Stratford Place, W. 1, London, England. The price is about $8.75.

Include Five New Methods in British Standard 9th Edition

Standard Methods for Testing Petroleum and its Products. Ninth Edition, Institute of Petroleum (British); 5½ x 8½ in., 616 pages, illustrated, indexed, paper binding, $6.75.

The new 9th edition of the British Institute of Petroleum's Standard Methods adds five additional procedures to an already extensive list. Included are new methods for estimating inorganic constituents in used and unused lubricating oils, spectrographic analysis for inorganic constituents in petroleum ashes, measurement of oil separation on storage of grease, and knock-rating of aviation fuels when used under supercharged rich mixture conditions.

New Opinion on Origin of Lines Given in Spectroscopy Study

The Interpretation of Spectra, by William Mayo Venable; 6 x 9 in., 206 pages, stiff cloth binding, indexed, illustrated, $6.00.

This new book on *The Interpretation of Spectra* is of value for at least two reasons: 1) the growth in the use of analytical and control instruments of the spectroscopic type in recent years requires more works helpful to the laboratory personnel operating such devices, and 2) it presents an interesting new opinion regarding the origins of spectral lines.

A set of tables, collected for convenience in reference at the end of the book, contain data not available elsewhere regarding intimate relationships between spectra emitted by supposedly entirely different sources. "That such accurate mathematical relationships occur was not expected by the current theory concerning the origins of spectral lines," the author states in his preface.

The author has made an attempt to account for spectra without quantum assumptions or any other assumptions contrary to mechanical and electro-magnetic principles commonly used in engineering, as in the design of dynamo-electric machinery, transformers, cyclotrons, electron microscopes, and communication by telephone or radio.

Mr. Venable is a consulting engineer for the Blaw-Knox Co., Pittsburgh.

New Book Lists 851 References On Oil from Oilseed Extraction

Literature Search on the Solvent Extraction of Oleaginous Materials, by B. H. Weil, Marjorie Bolen and Nathan Sugarman; 5½ x 8½ in., 185 pgs., indexed, stiff cloth binding, $4.00 (Feb., 1948).

This book is strictly a listing of 851 literature and patent references, with abstracts, pertaining to the solvent extraction of oil from oilseeds, a subject of interest to some petroleum technologists because petroleum naphthas are commonly used.

It has been prepared as Special Report No. 26 of the State Engineering Experiment Station, Georgia School of Technology, with which the authors are associated, and is offset printed from typewritten copy.

MEETINGS . . . for the Oil Man

June

1-6, Liquefied Petroleum Gas Assn., annual convention and trade show, State Fair Grounds, Sacramento, Calif.

6-11, Society of Automotive Engineers, semi-annual meeting, French Lick Springs Hotel, French Lick, Ind.

21-25, American Society for Testing Materials, 51st annual meeting, Book-Cadillac Hotel, Detroit.

August

18-20, Society of Automotive Engineers, west Coast meeting, St. Francis Hotel, San Francisco.

30-Sept. 3, American Chemical Society, 114th national meeting, Eastern Session, Washington.

September

6-10, American Chemical Society, 114th national meeting, Midwest Session, St. Louis, Mo.

13-17, Third Instrument Conference and Exhibit, Convention Hall, Philadelphia.

13-17, American Chemical Society, 114th national meeting. Western Session, Portland, Ore.

15-17, National Petroleum Assn., Hotel Traymore, Atlantic City, N. J.

15-17. American Institute of Chemical Engineers, regional meeting, French Lick Springs, Ind.

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18 years continuous service . . . savings up to 50% on the cost of tubes . . . records like these have been rung up by scores of heat exchangers tubed with Alcoa Aluminum Heat Exchanger Tubes. Figure your next retubing job in aluminum. You'll be amazed at the lower cost of the tubes, you'll be pleased with the long service and low maintenance these tubes will give.

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PERSONALS

Petroleum Technologists in the Headlines

Dr. Charles L. Thomas, director of research of the Great Lakes Carbon Corporation, has been elected chairman of the Chicago Section of the American Chemical Society, it is announced.

Dr. Thomas

Dr. Thomas will assume office on July 1, succeeding **Dr. Herbert E. Robinson,** assistant director of research of Swift & Company.

Dr. Thomas was co-inventor of synthetic silica alumina, a catalyst, or chemical stimulant, first used on a wide scale for cracking petroleum during the recent war in the production of aviation gasoline, and now extensively employed in making motor fuel. He recently received his one-hundredth United States patent, and he is the author of numerous articles on hydrocarbons, catalysts and the catalytic reactions of hydrocarbons.

He has been director of research at the Great Lakes Carbon Corporation since 1945. Before joining Great Lakes Carbon he was for fourteen years associated with the Universal Oil Products Company, Chicago, as a research chemist and associate director of research.

In 1931 he received the Ph. D. degree from Northwestern University, where he had been a fellow for two years. He received the B.S. degree in 1928 and the M. S. in 1929 from the University of North Carolina. He was born at Hendersonville, N. C., in 1905.

Besides the American Chemical Society, Dr. Thomas is a member of the American Institute of Chemical Engineers, the American Institute of Chemists, the American Petroleum Institute and the Society of Automotive Engineers.

* * *

Lawrence T. Haugen, a former naval captain attached to the Navy's Bureau of Ships as assistant chief of administration, is construction superintendent of Stanolind Oil & Gas Co.'s manufacturing department. During the war he was force constructor and material officer of the North Atlantic Task Force, supervisor of shipbuilding in the Pittsburgh area and planning officer of the Pearl Harbor Navy Yard. He is a graduate of the Naval Academy and holds a degree in naval construction from Massachusetts Institute of Technlogy.

* * *

Abert V. Collins has resigned his position as assistant chief chemist at Shell Chemical Corp., Houston, to become associated with The McGean Chemical Co., in Cleveland, Ohio.

* * *

Frank P. Tighe has left his position as director of public relations and advertising with the Houdry Process Corp. to return to the Chilton Co. as editor of MOTOR AGE. Long active in the automotive trade journal field, Mr. Tighe was originally associated with the Chilton organization in 1925, and as managing editor brought out the first edition of the new MOTOR AGE in 1935. During the last war, he served as head of the business magazine section of the Office of Censorship in Washington.

* * *

John A. Britton, Jr., vice president since organization in 1947 of Enjay Co., Inc., chemical products marketing affiliate of Esso Standard Oil Co., has been elected president. He succeeds **H. W. Fisher,** who continues as a director of Enjay and as general manager of East Coast manufacturing and manager of the chemical products department of Esso Standard.

Mr. Britton

Mr. Tracy

Mr. Britton has been associated with Standard of New Jersey and its affiliated companies for 27 years, being largely concerned with the development and sale of additives and synthetic rubbers.

O. V. Tracy, assistant manager of Esso Standard's chemical products department, has been named a director of Enjay, succeeding **Dr. H. G. Burks, Jr.** He joined the Jersey Standard family in 1939 and has been associated with the development of synthetic rubbers, alcohols, additives and other chemicals.

J. B. Rogerson, formerly refinery superintendent for Lion Oil Co., El Dorado, Ark., has been made manager of manufacturing, and will be in charge of both refinery and chemical plant operations of the company. **W. M. Carney** has been promoted from assistant to refinery superintendent.

Mr. Rogerson

Mr. Rogerson, a native of Arkansas, graduated from the University of Arkansas in 1920 with a B.S. in mechanical engineering. He has been with Lion Oil Co. for 21 years as plant engineer, chief engineer and refinery superintendent. Mr. Carney received his college training at the University of Arkansas and Oklahoma University. He has been in the refining division of Lion Oil Co. since 1925.

* * *

D. R. Johnson and **J. E. Fenex** have been named to the recently established positions of regional superintendents for Continental Oil Co. Mr. Johnson, superintendent of the Ponca City refinery, will supervise southern region refineries, including plants at Ponca City; Lake Charles, La.; Wichita Falls, Texas and Artesia, N. M. Mr. Fenex, superintendent of the Lake Charles refinery, will direct the western region, including plants at Denver; Glen Rock, Wyo.; Farmington, N. M. and the new refinery being built at Billings, Mont.

L. W. Vickery, assistant superintendent since 1943 at the Ponca City refinery, succeeds Mr. Johnson as superintendent. **H. R. Wall,** assistant superintendent at Lake Charles since 1942, succeeds Mr. Fenex.

* * *

T. A. Atkinson has been named manager of industrial relations for General Petroleum Corp., Los Angeles. He has been assistant manager. He is a graduate in mechanical engineering from the University of California.

* * *

Edward L. Ghormley, formerly with California Research Corp., has joined the staff of George Armistead, Jr., consulting engineer, Washington, where he will be engaged in process and design engineering. He recently completed graduate work at Massachusetts Institute of Technology.

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MAX. PRESSURE
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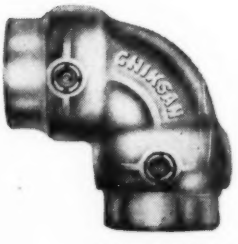

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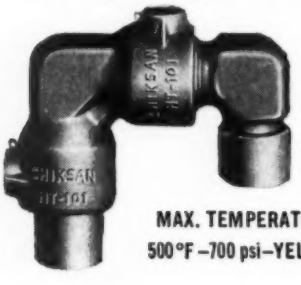

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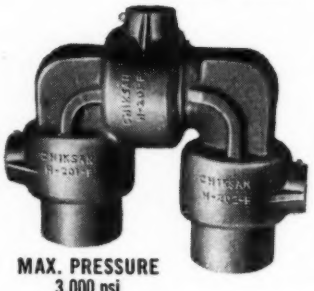
500°F–700 psi–YELLOW



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Personals

S. A. Swensrud, executive vice president of Gulf Oil Corp. since May 1947, has succeeded **J. F. Drake** as president. Mr. Drake, president of Gulf since 1931, becomes chairman of the board.

Mr. Swensrud

Mr. Swensrud, a native of Iowa, is a graduate of the University of Minnesota and received his M.B.A. degree from Harvard University Graduate School of Business in 1927 and stayed on as member of the Harvard Business School staff. In 1928 he went with Standard Oil Co. of Ohio as assistant to the president, becoming vice president in charge of production, supply and transportation in 1939, and in 1946 was made executive vice president.

Mr. Swensrud has been active in general industry affairs and during the war he served on various committees advisory to PAW, the Petroleum Industry War Council and the Office of Price Administration.

* * *

Appointment of **Warren K. Venatta** as manager of product control is announced by Oronite Chemical Company, subsidiary of Standard Oil Company of California.

In his new position, Venatta will co-ordinate production availability with requirements.

Venatta joined California Research Corporation, Standard's research subsidiary, in 1939 following his graduation from the University of Wisconsin as a chemical engineer. He started at the El Segundo laboratories as an assistant engineer in technical service and since 1943 has been a group supervisor in charge of gasoline synthesis. His work has been principally connected with alkylation, isomerization and propylene polymerization.

* * *

Wheeler G. Lovell, for the past 21 years assistant head of the Organic Chemistry Department of General Motors Research Laboratories, is now with the Ethyl Corp. Research Laboratories in Detroit as an associate director of research in the basic combustion field.

* * *

Wayne W. Carter, formerly in the Research Department of the Elliott Co., Jeanette, Pa., is now a mechanical engineer in the Automotive Division of the Research and Development Department of Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

Personals

Dr. Claude C. Peavy, chief engineer for Houdry Process Corp. for several years, has been made vice president in charge of sales and engineering. Prior to joining Houdry, he was for five years chief process engineer for Socony-Vacuum Oil Co., Inc.

* * *

W. W. Davison, formerly general manager of the El Segundo refinery of Standard Oil Co. of California, has been elected a vice president of the company. He graduated from the University of California in mechanical engineering in 1921 and joined Standard as an engineer's helper at El Segundo. He became assistant chief engineer and design engineer and in 1928 was assigned to the manufacturing department.

Mr. Davison

In 1936 Mr. Davison became refinery superintendent at Vancouver for Standard Oil Co. of British Columbia, Ltd. In 1940 he was transferred back to the El Segundo refinery as assistant superintendent and in 1943 became assistant manager and the following year plant manager.

C. J. Tighe has joined Stanolind Oil & Gas Co. as field project engineer in charge of construction of the company's gasoline plant near Ulysses, Kans.

* * *

Wayne C. Edmister, who supervised process design of the atomic pile (nuclear reactor) at Brookhaven National Laboratory, Long Island, has been appointed professor of chemical engineering at Carnegie Institute of Technology, Pittsburgh. He has been senior chemical engineer and assistant director of process development for Hydrocarbon Research, Inc., New York, and is adjunct professor of chemical engineering at New York University.

Product Development

Reprints have been made of the article "Product Development in the Petroleum Chemical Field" by Richard W. Kix-Miller, which was published in the March issue of PETROLEUM PROCESSING, page 241. Readers may obtain single copies, without charge, by addressing a request to:

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WANTED: Piping designers with 5-10 years' experience, preferably in oil refining. Age 25-40. Salary over $5,000 per year. Opportunities for advancement. Write, stating qualifications, to Mr. E. G. Glass, Jr., The Standard Oil Company (Ohio), 1780 Midland Building, Cleveland 15, Ohio.

ADVERTISERS' INDEX

This index is published as a convenience to the reader. Every care is taken to make it accurate but Petroleum Processing assumes no responsibility for errors or omissions.

Allied Chemical & Dye Corp., 518-Inside Back Cover
Aluminum Co. of America 553-605-612
American Cyanamid Co. 522
Babcock & Wilcox Co. and/or Tube Co. 607
Badger & Sons Co., E. B. 560-561-582
Brown Fintube Co. 598
Calumet & Hecla Consolidated Copper Co. ... 520
Carrier Corp. 578
Chase Brass & Copper Co. 543
Chicago Bridge & Iron Co. 519
Chiksan Co. 614
Cooper Alloy Foundry Co. 550
Crane Co. 564
DuPont de Nemours & Co., Inc., E. I. Facing Pg. 592
DuPont de Nemours & Co., Inc., E. I. Facing Pg. 545
Durametallic Corp. 570
Emery Industries, Inc. 587
Enjay Co., Inc. 568
Erie Bolt & Nut Co. 609
Ethyl Corp. 513
Filtrol Corp. 557
Foster Wheeler Corp. ..... Facing Pg. 528
Foxboro Co., The 514
General Chemical Division of Allied Chemical & Dye Corp. ..... Inside Back Cover
Graver Tank & Mfg., Co., Inc. 562
Griscom Russell Co. 554
Hammond Iron Works 525
Harshaw Chemical Co., The 591
Hudson Engineering Corp. ..... Inside Front Cover
International Nickel Co., Inc. 588
Jerguson Gage & Valve Co. 579
Johnston & Jennings Co., The 575
Kellogg Co., M. W., The 526
Koch Engineering Co. 521
Ladish Co. ..... Facing Pg. 544
Lukens Steel Co. 581
Lummus Co., The ..... Facing Pg. 576
Metasap Chemical Co. 609
Monsanto Chemical Co. 610
McKee & Co., Arthur G. 530
National Annealing Box Co. 606
National Foam Systems, Inc. 603
Oliver United Filters, Inc. 529
Petroleum Rectifying Co. 548
Powell Co., Wm., The 597
Quaker Oats Co., The 584
Sargent & Co., E. H. 604
Solvay Sales Division of Allied Chemical & Dye Corp. 518
Strong, Carlisle & Hammond Co. 608
Taylor Manufacturing Co. 596
Universal Oil Products Co. 516-517
Warner Lewis Co. 571
Warren Petroleum Corp. 572
Wolverine Tube Divn. 520
Worthington Pump & Machinery Corp. 594
Wyatt Metal & Boiler Works .. Outside Back Cover

EDITORIAL VIEWPOINTS...

Opinions and Comments on Current Topics

Butane Utilization Problem Also Has Economic Aspects

THE PROBLEM of butane utilization in motor fuels is concerned with more than handling the rapidly increasing supplies of this light hydrocarbon produced from refining operations and natural gas processing. Economic aspects are involved, chiefly through the higher evaporation tendencies of this more volatile material, in the handling and storage of motor fuels from the refiner to the automotive vehicle and, finally, in its consumption in the car engine.

To merely state some of the factors involved, as they were presented before the API Division of Refining at Philadelphia, will give an idea of the complex nature of the problem. Refiners, for example, will have to consider from their own individual positions, whether it is economically desirable for them to include the butanes they manufacture as such in their motor fuels, or whether to convert them by chemical processes into low vapor pressure components. They may find it desirable to install processes that add the least to their own supply of butanes in order to take advantage of the increasing volumes of butanes available on the outside.

If butanes as such are included in motor gasoline, will they be lost through evaporation at various stages in handling and storage of the motor gasoline? Impressive figures were presented to show that evaporation losses at the carburetor alone, with higher vapor pressure fuels, could account for more than half the butane added. Here the problem would seem to involve the designing by automotive engineers of a carburetor to work at temperatures approaching atmospheric.

In the final analysis, as was expressed at the API meeting, the problem may resolve itself around the economic factor of where the least money will have to be spent to carry the butane through to final consumer utilization; by the refiner for the chemical processes to convert butanes to low vapor pressure motor fuels, or by the car manufacturer to design and build fuel systems for higher vapor pressure fuels.

Unit Refining Costs Higher Despite Larger Volume Output

EXCEPT FOR THE higher prices which refiners received for their products in 1947, greater attention likely would have been given to the fact that unit refining costs, which have been advancing during the war, were higher than for the previous year. The volume of crude processed and of products manufactured was greater, in some cases by more than 10%, than in 1946. Under these circumstances, in normal times a lower unit manufacturing cost would be anticipated. This was not the case under present operations, however, as is pointed out in the annual reports of some of the oil companies.

Increased prices paid for materials aside from crude oil used in refining, and for materials used for repairs and maintenance of operating facilities, higher costs for services of outside contractors and, of course, higher cost of labor contributed to the increased unit refining cost.

Standard Oil Co. (Ohio), for example, reported its refineries processed about 12% more crude than in 1946, the previous high year. Incidentally, this was twice the volume processed in 1938, the growth being accomplished with what is described as "only a moderate outlay for new plants and equipment". However, refinery operating costs per barrel of crude processed in 1947 were about 9% higher than in 1946, it was reported.

The Atlantic Refining Co., pointing out that unit costs of virtually every oil company operation had increased, stated its unit refining cost last year was two-thirds greater than in the immediate prewar years. Increases in prices received for crude oil and products have not kept pace with the rising costs of labor and materials and of finding, producing and processing crude, states the annual report of Cities Service Co.

Of the factors contributing to the higher unit refining cost today, the only one that plant management and supervisors can influence to any great extent is the cost of labor, through working to increase its productivity, reduce the rate of turnover and so on. Continental Oil Co. stated it reduced the turnover rate in its manufacturing operations from 24.2% in 1946 to 10.1% in 1947. With an investment in employes at over $20,000, as set by one company, four times that of the average manufacturing business, the effect of a reduced rate of labor turnover on operating costs is evident.

Special training programs for foremen and supervisors have been set up by some of the larger plants. Such programs could be directed not only to improve the quality of supervision, which would be reflected in worker productivity and rate of turnover, but also to enlist the directing personnel in the general effort to halt advancing unit operating costs.

Training New Professional Workers

THIS SEASON of the year finds the ranks of refinery workers augmented by graduate engineers, chemists and other types of professional workers fresh from school. Where these men go into the large refineries, in many cases they find special training programs set up, which take the place of the "pick and shovel route", by which the professional men were introduced to the practical side of industry in the past.

The benefits of organized training programs for these men, as well as for the craftsmen and plant operators, are obvious. The new professional men start in with equal opportunity to learn and advance, better opportunity is afforded for evaluation of the individual's abilities, and the individual new worker can be given a balanced outlook toward the industry and the particular company where he has thrown his fortunes.

However, what about the graduate engineer or chemist who leaves the classroom to go into a smaller plant where he may be one of few, or perhaps the only newcomer among professional men? The need is just as great as in a large plant to provide for an orderly induction period for such individuals. This is a phase of organized plant training practices which the API Committee on Training in Refining could include in its overall study of this subject.

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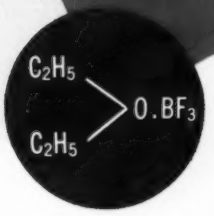

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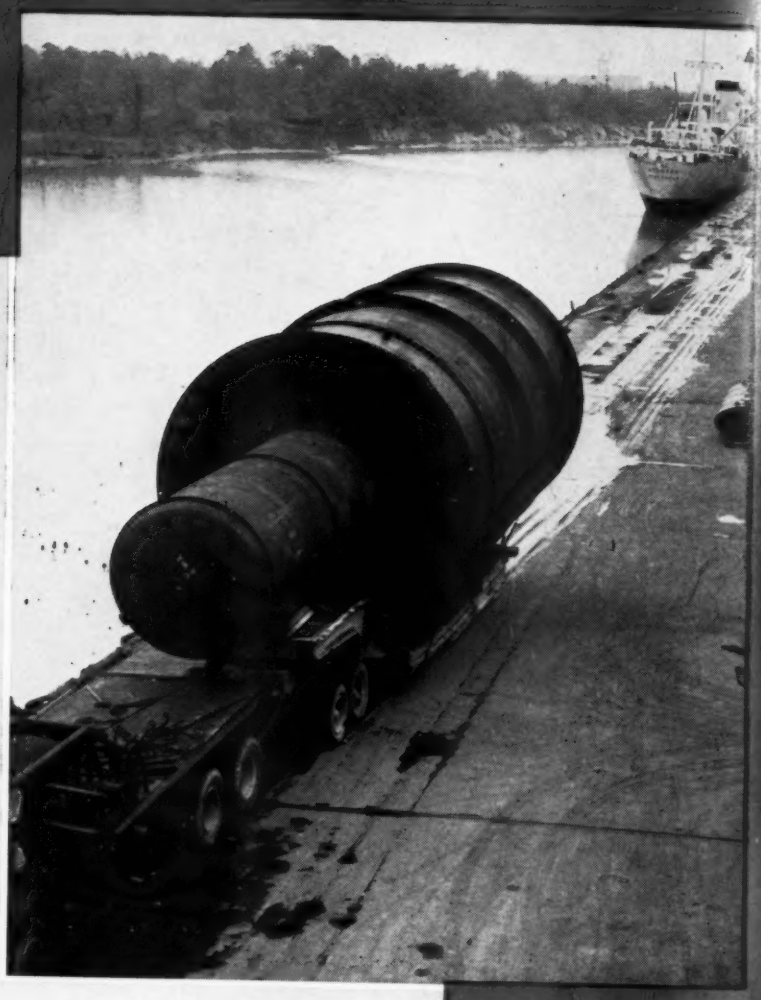

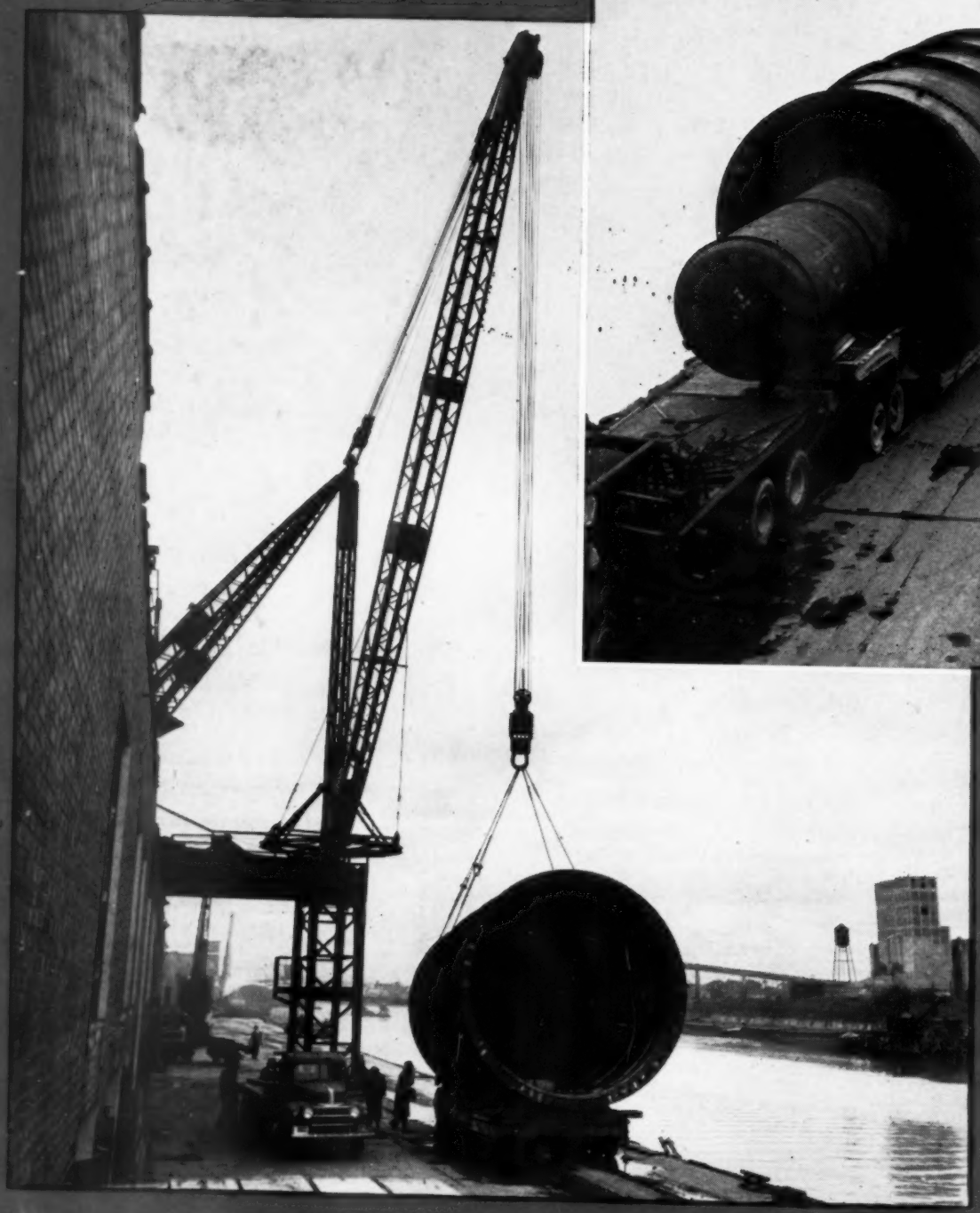

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